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HOUSE OF REPRESENTATIVES

DURING THE

SECOND SESSION OF THE FORTY-FIRST CONGRESS.

1869-'70.

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GOVERNMENT PRINTING OFFICE.
1870.

INDEX

TO

THE EXECUTIVE DOCUMENTS

OF THE

HOUSE OF REPRESENTATIVES OF THE UNITED STATES

OF THE

SECOND SESSION OF THE FORTY-FIRST CONGRESS.

REPORT

OF

THE SECRETARY OF WAR,

BEING PART OF THE

MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE SECOND SESSION OF THE FORTY-FIRST CONGRESS.

VOLUME II.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1869.

REPORT

OF

THE CHIEF OF ENGINEERS

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 25, 1869.

GENERAL: I have the honor to present for the information of the General of the Army, in accordance with the instructions of the Secretary of War of the 23d instant, the following report of the duties devolving upon the Corps of Engineers for the fiscal year ending June 30, 1869:

OFFICERS OF THE CORPS OF ENGINEERS.

The number of officers in the Corps of Engineers at the end of the year was one hundred and eleven on the active list, and six on the retired. In addition, the corps was aided by officers detailed from other arms of the service, and a number of civil engineers, geologists, &c., &c.

Since the last report the corps has lost by death an able and distinguished officer, Major M. D. McAlester, brevet brigadier general United States Army. There has been one resignation during the year, and one officer has been retired.

On June 30, 1869, the officers were distributed as follows:

On duty in the office of the Chief of Engineers, including the Chief	6
On duty with boards of engineers for fortifications	7
On duty with battalion of engineers	23
On duty, construction of fortifications	8
On duty, construction of river and harbor improvements	18
On duty, construction of fortifications, and river and harbor improvements	21
On duty in charge of public buildings, grounds, &c	1
On duty, survey of the lakes	6
On special duty	1
On leave of absence till date of resignation	1
Awaiting orders	1
Detached on duty with generals commanding divisions, departments, &c	22
Retired, off duty	2
Total	117

The officers detached were on duty as follows:

Brigadier General Richard Delafield, brevet major general United States Army, and Colonel Hartman Bache, brevet brigadier general United States Army, members of Light-house Board	2
Major C. B. Comstock, brevet brigadier general United States Army, aide-de-camp to the General of the Army	1

Major O. M. Poe, brevet brigadier general United States Army, engineer, secretary to Light-house Board	1
Major Henry M. Robert, on staff of major general commanding military division of the Pacific	1
Major Wm. E. Merrill, brevet colonel United States Army, on staff of the lieutenant general commanding military division of the Missouri	1
Major O. E. Babcock, brevet brigadier general United States Army, on duty with the President of the United States	1
Captain G. L. Gillespie, brevet lieutenant colonel United States Army, engineer tenth light-house district	1
Captain George Burroughs, brevet major United States Army, engineer sixth light-house district	1
Captain Wm. J. Twining, brevet major United States Army, on staff of commanding general department of Dacotah	1
Captain G. J. Lydecker, brevet captain United States Army, engineer eighth light-house district, west of Pearl River	1
Captain Charles B. Phillips, brevet captain United States Army, on staff of commanding general department of Missouri	1
Captain Chas. W. Raymond, on temporary duty at headquarters military division of the Pacific	1
Captain Lewis C. Overman, on staff of commanding general fifth military district	1
First Lieutenant George M. Wheeler, on staff of commanding general department of California	1
Captain P. S. Michie, brevet lieutenant colonel United States Army, Captain W. H. H. Benyaurd, brevet major United States Army, First Lieutenant M. R. Brown, First Lieutenant James C. Post, First Lieutenant Henry M. Adams, First Lieutenant James Mercur, and First Lieutenant Charles E. L. B. Davis, on duty at Military Academy	7
	22

The following officers of the army were on duty during the year under my orders, namely: Brevet Major General J. H. Wilson, lieutenant colonel United States Army; Second Lieutenant E. T. Hoffman, United States Army.

The following principal civil engineers and geologists were employed during the year: W. Milnor Roberts, Clarence King, H. C. Long, and D. C. Jenné, while besides these were many others employed as assistants on the works of survey and improvement.

SEA COAST AND LAKE FRONTIER DEFENSES.

During the past year very moderate progress has been made, and only upon those portions of the defensive works no questions concerning which are involved in the solution of the problems that are the subject of experiment. Progress was thus restricted, because of the smallness of the appropriations for fortifications. Much larger sums have been asked for by me, and could be used with advantage as well as economy.

Investigations relating to the use of metals for defensive purposes have been continued, and with results which have at least shown in what cases we cannot yet enter upon the use of materials, the preparation of which in this country has not attained the perfection which our pur-

poses require, and suggest the question whether the results reached in other countries have proved satisfactory. But little information is made public in Europe upon the subject. It cannot be ascertained whether the use of iron or its compounds has been definitely adopted as a constituent of those parts of defensive works that are exposed to the fire ot heavy artillery, while thus far it appears that in its application to ships this metal does not afford the desired resistance to heavy shot.

In these investigations varieties of iron from different parts of the country have been procured and tested, and experiments have been made with lead concrete in combination with iron, and with several other forms of compound targets. These experiments were made with a gun of small caliber, and in connection with a testing machine and other apparatus; some of the tests applied being such as to develop information relative to the use of the materials for purposes of civil as well as military engineering. A detailed report of these experiments has been nearly completed, which should be printed and distributed to the corps.

The importance of securing additional cover for barbette guns in earthen batteries, a point also presented in last year's report, has received due attention. Drawings and descriptions of numerous inventions for this purpose have been collected and distributed to the corps, and several new devices have been originated by officers of engineers. One of these latter, a modification of the present barbette carriage and platform, mounting a fifteen-inch gun, has been tested experimentally with maximum charges of 100 pounds of powder, and solid shot weighing 432 pounds. The results are believed to justify the opinion that this method of mounting guns is not only practicable so far as to secure the necessary cover, but that our heavy guns may be worked in this manner with a reasonable number of men, and without the aid of steam power or other auxiliaries of questionable utility.

The magnitude of this experiment compares with that of Captain Moncrieff, the only similar one of which we have information, as follows:

Weight of gun	50,000 pounds.
Weight of shot used in the experiments, (old pattern).	432 pounds.
Weight of charge	100 pounds.
Caliber of gun	15-inch.
Descent of gun during recoil	5 feet.
Weight of gun, (Captain Moncrieff's)	15,000 pounds.
Weight of shot ....do	115 pounds.
Weight of charge ....do	22 pounds.
Caliber of gun ....do	7-inch.
Descent of gun during recoil .do	3 feet.

The experimental structures at Old Point Comfort and Fort Delaware mentioned in last year's report, have been completed and subjected to the necessary firings. Several important results have been developed by these trials. It may be anticipated that with further research and deliberation the use of iron will be found practicable in shielding casemate guns in our existing masonry casemates, in cases where such protection is considered necessary. The present difficulties are its excessive cost, and the insufficiently developed condition of the processes of metal working in this country. Before applying iron or its compounds as a sole material for gun covers in new works, its cost must be reduced and the means of supplying it must be increased.

For these reasons it appears to be inexpedient at present to press the question of the special employment of iron in our defensive works to a solution which would probably be premature. While investigation

as to such employment goes on, it is proposed to strengthen our defenses by the use of approved materials, and by the introduction into them of elements and accessories, the value of some of which has been developed by the events of our late civil war, while the changes in naval construction have given a prominence to others heretofore recognized as serviceable, but which have not as yet been systematically applied.

Such accessories and meliorations of our works, with comparatively few casemate covered guns, will as fully assure as heretofore the security of our great seaboard cities, naval establishments, and harbors of refuge and rendezvous.

As the early completion of these proposed modifications of our defenses involves only moderate expenditures, it is earnestly recommended that Congress provide for this by making the requisite appropriations.

To exhibit the subject somewhat more in detail, it is to be said the board of engineers for fortifications, to which was committed the duty of preparing the experimental structures referred to, and of making the necessary trials of them, presented the following conclusions in their report upon the subject, recommending:

First. The preparation at appropriate positions of powerful barbette batteries for the largest calibers of guns, carefully protected by traverses and parados, and liberally furnished with magazines and bomb-proofs.

Second. The substitution of a depressing gun-carriage for the model now in use. This substitution will provide for the descent of the gun upon discharge entirely below the level of its earthen covers, so that the piece and its gunners will be thoroughly sheltered from an enemy's fire.

Third. The free introduction of large mortars in the defensive arrangements. These will act effectively upon the thin decks of vessels whose sides are heavily armored; and they admit of being placed upon ground not suitable for gun batteries, are easily isolated and covered, and of moderate cost.

Fourth. The employment of torpedoes as an accessory, using the engineer battalion for experimentally developing the system and for applying it to actual defense. Torpedoes are of litttle cost, can be easily preserved, and readily placed in position. Their value has been well shown in the Crimean war, in the Baltic, and in our southern waters during our late war.

Fifth. The use of obstructions and floating batteries, as heretofore recommended in previous projects for the defense of our coast.

The views of the board are in accordance with my own convictions, and have been approved by the General of the Army and by the Secretary of War, upon being laid before them by me, with favorable recommendation.

Specific projects for the defense of our principal ports and harbors are now in process of preparation, in conformity with these approved determinations, and it is for the execution of these, so far as presented, as well as for the furtherance of work already in progress which conforms to these views, and for necessary repairs and preservation of sites, that the estimates of the year have been made. It is hoped they will receive the approval of Congress.

The board of engineers for fortifications has already submitted the projects, in great part, for modifying the defenses of New York, Philadelphia, and Boston, and a brief statement in relation to them will be found under the heading of each work or position, together with the estimates of cost.

At other points similar meliorations, in a greater or less degree, have been considered in preparing the estimates for the next fiscal year.

FORTIFICATIONS.

Fort Wayne, Detroit, Michigan, in charge of Colonel T. J. Cram, brevet major general United States Army.—Operations at this work have been carried on through the year, resulting as follows: The widening of the ditch has been completed, and its bottom covered with soil and seeded. The embanking, soil-covering, and sodding of the counterscarp have been completed except at the demilune. The glacis has been completed on the northwest or land front, and the east face of the north bastion, and the counterscarp raised to the same height as for the rest of the counterscarp of the main work. At the foot of the glacis an open ditch for drainage has been constructed and sodded. The gap left in the scarp of the main work for communication has been appropriately filled. Nothing has been done on the lateral exterior batteries except embanking in their parapets five hundred and fifty cubic yards of earth from the ditch, and the making of the arch centers and doors of the magazines. A substantial fence to inclose the glacis has been commenced. The old cellar excavations have been completely filled, leaving the parade ground in good condition. The operations contemplated for the present year are: To complete the fence and drain around the foot of the glacis; to complete the thickening of the embankment in front of counterscarp crest; to cover the arch of the demilune magazine with mastic and earth; to complete soiling and seeding the glacis, and to remove the present road leading from the engineer dock out, so as to be exterior to the lateral battery.

No appropriation asked for the next fiscal year.

Fort Niagara, mouth of Niagara River, New York, in charge of Lieutenant Colonel C. E. Blunt, brevet colonel United States Army, Major M. D. McAlester, brevet brigadier general United States Army, and Major Nicholas Bowen, brevet colonel United States Army.—During the past year the force on this work has been employed as follows: The sallyport arch and entrance, with parapet above it, have been completed; casemate arches concreted, covered with mastic and finished; entrance to flank casemate completed; rampart and parapet of the flanks have been extended forward to the scarp wall; brick masonry of the flanking gallery finished except the coping; the walls of the small postern communicating with the gallery have been built and the arch turned; all dry stone filling behind walls finished, and the old scarp timbers entirely removed. During the year ending June 30, 1870, it is intended to continue and complete the land front, and repair United States buildings, wharf and crib jetties.

No appropriation asked for the next fiscal year.

Fort Ontario, Oswego, New York, in charge of Lieutenant Colonel C. E. Blunt, brevet colonel United States Army, Major M. D. McAlester, brevet brigadier general United States Army, and Major Nicholas Bowen, brevet colonel United States Army.—During the past year the force on this work has been engaged on the scarp wall; forming and sodding parapet of front No. 4; completing the masonry and joiners' work of the two guard-houses, and making them ready for occupancy. During the year ending June 30, 1870, it is proposed to continue the raising of the scarp-wall on all fronts to the required references; commence masonry of loop-hole galleries of bastions D and E, and quarry and dress stone for same; continue the formation of parapets and slopes; grade and drain the ditch; make and hang gates for sallyports, &c.

No appropriation asked for the next fiscal year.

Fort Montgomery, outlet of Lake Champlain, New York, in charge of

Captain J. W. Barlow, brevet lieutenant colonel United States Army.—During the year staircase bastion C has been raised to the height of 39′.78; the adjoining pier completed; the south end of parade wall of curtain III raised to 39′.58, and that of the west end of curtain II to 38′.33. The last main arch and drain of curtain III and the remaining two of bastion C have been turned. The second floor arches of one suite of rooms in the quarters, and the roofing of curtain III and bastion C, have been completed. The terreplein of the former and a part of the latter have been filled with earth. The stone facing of the west salient of cover-face has been raised to its full height, and the cover-face embanked with earth.

It is proposed to replace the wooden floors of curtains I and V, and bastions A and E, with masonry; rebuild counterscarp, and make some other necessary repairs.

Appropriation asked for the next fiscal year, $65,000.

Fort Knox, Bucksport, Penobscot River, Maine, in charge of Lieutenant Colonel George Thom, brevet brigadier general United States Army, and Lieutenant Colonel James C. Duane, brevet brigadier general United States Army.—During the past fiscal year the exterior slope of the north covered way was rebuilt with a stone facing of rough granite to a reference of eight feet below the interior crest, and repairs of the northern and western exterior slopes of the northeast place-of-arms were completed.

Appropriation asked for the next fiscal year, $25,000.

Fort Popham, mouth of Kennebec River, Maine, in charge of Lieutenant Colonel George Thom, brevet brigadier general United States Army, and Lieutenant Colonel James C. Duane, brevet brigadier general United States Army.—The appropriation for this work having been exhausted, operations were suspended and no expense, except for the care and preservation of the work. has been incurred. At the close of the year ending June 30, 1869, a board roofing was built over the unfinished casemates of the fort to protect them against the weather.

Appropriation asked for the next fiscal year, $25,000.

Fort Gorges, Portland Harbor, Maine, in charge of Lieutenant Colonel George Thom, brevet brigadier general United States Army, and Lieutenant Colonel James C. Duane, brevet brigadier general United States Army.—During the past year the two magazine traverses on the gorge, and the bomb-proofs on fronts I, IV, and V, of the barbette tier, were completed. On the completion of these operations—the appropriation having been exhausted—fronts II, III, IV, and V, and the angles I–VI and V–VI, as well as the finished bomb-proofs and magazines, were covered with a substantial board roofing for protection against the weather. One hall and six rooms in the quarters were finished during the year.

Appropriation asked for the next fiscal year, $25,000.

New Fort Preble, Portland Harbor, Maine, in charge of Lieutenant Colonel George Thom, brevet brigadier general United States Army, and Lieutenant Colonel James C. Duane, brevet brigadier general United States Army.—During the past year the magazine traverse in the south battery was completed. The excavation for the new magazine in the old inclosed work was executed; the foundation walls built, and the walls of the magazine carried up to the spring line of the arches. A portion of the parade in the rear of the water fronts was filled in. Scarps A and B (new fronts of old inclosed work) and gun platforms and recesses were pointed. A considerable quantity of stone was dressed for the magazine, and the brick barracks in the inclosed work were demolished.

Appropriation asked for the next fiscal year, $50,000.

Fort Scammel, Portland Harbor, Maine, in charge of Lieutenant Colonel George Thom, brevet brigadier general United States Army, and Lieutenant Colonel James C. Duane, brevet brigadier general United States Army.—During the year magazine traverse C in the main work was built and the excavation for the drains leading from the magazine was completed. The site for magazine traverse B has been excavated.

Appropriation asked for the next fiscal year, $50,000.

Fort McClary, Portsmouth Harbor, Kittery Point, Maine, in charge of Lieutenant Colonel J. G. Foster, brevet major general United States Army.—No work has been done during the fiscal year except the receipt of materials previously contracted for, and guarding and preserving the materials and machinery on hand.

Appropriation asked for the next fiscal year, $75,000.

Fort Constitution, Portsmouth Harbor, New Hampshire, in charge of Lieutenant Colonel J. G. Foster, brevet major general United States Army.—No work performed except guarding and preserving the machinery and materials on hand.

No appropriation asked for the next fiscal year.

Fort Warren, Boston Harbor, Massachusetts, in charge of Colonel H. W. Benham, brevet major general United States Army.—The work of the fiscal year comprises the completion of the masonry and earth-work of the bomb-proof traverse of the cover face of front 2. The repairs of the casemate leaks in the officers' quarters, at each flank of front 3; the repairs of several land slides on the ravelin, upon cover-face of the gorge, (front 3,) and on the interior, below the ramps; the commencement of extensive repairs of leaks over casemates of front 2; the rebuilding of a carpenter's shop, and the essential completion of the rebuilding of the quarters of the engineer workmen. It is very important that this fine work, occupying so favorable a position for the defense of the anchorage of Nantasket Roads and the main outer channel, should be prepared, at as early a day as practicable, for as many of the most powerful sea-coast guns as can, with adequate protection, be placed in it without too great cost. A project for its modification in accordance with this view has been prepared. It is proposed to modify the principal barbette earthen batteries of the work in a manner to furnish emplacements for a large number of heavy guns, with the requisite magazine traverses and parados for protecting them against enfilade and reverse fires.

Estimated cost of modifications, $402,400. Appropriation asked for the next fiscal year, $200,000.

Long Island Head, Boston Harbor, Massachusetts.—The United States having, under the act of Congress approved March 28, 1867, acquired possession of this headland, well situated for the defense of Broad Sound and the main ship channel, it is proposed to construct upon it a barbette earthen battery for heavy guns, with the requisite magazine traverses and parados.

Estimated cost of battery, $175,000. Appropriation asked for the next fiscal year, $175,000.

Fort Winthrop, Boston Harbor, Massachusetts, in charge of Colonel H. W. Benham, brevet major general United States Army.—The operations at this work during the year have comprised the completion of the long bomb-proof tunnel-way, connecting the tower ditch and the south battery with its covering of asphalt and earth, and the construction of a bomb-proof traverse opposite the entrance to the tunnel (to protect it) on the south battery. The grading and sodding of the earthen counterscarp slopes on the north and west sides of the tower were finished, and

the grading of these slopes on the remaining sides has been nearly completed. The open covered way, or stairs, between the south and southwest batteries, has been constructed, and the surplus earth arranged in a parapet embankment for further protection. Several earth slides of the traverse slopes have been repaired, and the earthen parapet of the west front of the work around the tower has been commenced. It is expected that the whole west half of this outwork, except its breast-height wall, will be completed during the present working season. It is proposed to construct a sea-wall to protect the bluff in front of the east battery, and to arrange the covered ways of the keep for the reception of a battery of very large guns; to fit the east battery for a like armament, instead of its present artillery; to make similar alterations of the south and west batteries, and to provide new and modify existing magazines, traverses, and parados of the work, for the reception of larger supplies of ammunition, and for the better protection of the work against reverse or enfilade fire.

Estimated cost of the modifications, $138,000. Appropriation asked for the next fiscal year, $138,000.

Fort Independence, Boston Harbor, Massachusetts, in charge of Colonel H. W. Benham, brevet major general United States Army.—The work of the year has been essentially as follows: The construction of a magazine to the southeast exterior battery, and the completion of the bomb-proof traverse adjacent, with the regulation of the ground near; the repair of the slopes of the northwest exterior magazine, and the temporary protection of the southeast shore by an "apron" facing of rough stone. Plans for the modification of this work have been prepared. It is proposed to substitute for the present barbette armament a number of the largest guns, thoroughly protected by traverses, parados, and parapets of increased thickness.

Estimated cost of modifications, $106,000. Appropriation asked for the next fiscal year, $106,000.

Permanent defenses at Provincetown Harbor, Massachusetts.—The preparations of a project for the defense of this harbor will be undertaken by the board of engineers for fortifications as soon as practicable.

No appropriation asked for the next fiscal year.

Fort at Clark's Point, New Bedford, Massachusetts, in charge of Captain J. A. Smith, brevet major United States Army, and Major D. C. Houston, brevet colonel United States Army.—The work on this fort during the past year has been as follows: The first and second tiers have been completed, except quarters; the mastic covering of roof surfaces and magazines has been completed; the three barbette magazines have been finished excepting the wood work; the breast height wall, parapet and terreplein of gorge, and the two rectangular stair towers have been completed, the roof of one being occupied by the lantern of the light-house placed there during the year; the two circular stair towers have been temporarily roofed and windows closed; the iron railings in front of magazine doors have been constructed and put up with one exception, and the pointing of the entire masonry completed. The amount estimated to complete the work, exclusive of additional batteries, for which plans have been prepared, is $50,000.

Appropriation asked for the next fiscal year, $50,000.

Fort Adams, Newport Harbor, Rhode Island, in charge of Major D. C. Houston, brevet colonel United States Army.—The work on this fort has consisted in building shot beds, repointing masonry, uncovering and asphalting two arches in west front, repairing terreplein on east front, repairing sea-wall in front of fifteen-inch gun battery in southwest

cover-face, completing new guard-house in place-of-arms east front, refacing embrasures of west front, repairing permanent wharf, making new postern gates, repairing water-closets and pumps, building in southeast bastion, earth closets and urinal for soldiers' use, and hot-bed for drying earth for same, lackering iron railings and repairing sidewalks in main work, together with general repairs. The work contemplated for the year ending June 30, 1870, will consist in completing the earth-closets for soldiers' use, repairing brick embrasures of the fort, repointing the masonry where necessary, and making such other repairs as are necessary for the preservation of the work. To construct permanent quarters for officers, and effect necessary repairs and alterations of the fort, an appropriation is desired.

Appropriation asked for the next fiscal year, $150,000.

Defenses of Dutch Island, western entrance to Narragansett Bay, Rhode Island, in charge of Major D. C. Houston, brevet colonel United States Army.—The operations on these works during the past fiscal year have consisted in altering the upper barbette battery to adapt it to an armament of fifteen-inch guns, constructing two service magazines, completing permanent wharf, repairing buildings, boats, and temporary wharf, and grading and draining in rear of fifteen-inch gun battery.

No appropriation asked for the next fiscal year.

Fort Trumbull, New London Harbor, Connecticut, in charge of Major D. C. Houston, brevet colonel United States Army.—The work at this fort during the year has consisted in repointing the parade wall, and in the care of the work by a fort-keeper.

No appropriation asked for the next fiscal year.

Fort Hale, New Haven Harbor, Connecticut, in charge of Major D. C. Houston, brevet colonel United States Army.—Nothing beyond making and hanging a gate at the entrance to the reservation has been done during the year. The work has been cared for by a fort-keeper.

No appropriation asked for the next fiscal year.

Fort Schuyler, East River, New York, in charge of Major H. L. Abbot, brevet brigadier general United States Army.—Operations during the past year have been confined to completing the work on the new magazines, and gun platforms of the cover-face, to making necessary modifications of the casemates of the second tier to adapt them to receive the new iron carriages of the eight-inch guns, to supplying the main magazines of the fort with wire gauze gratings and galvanized iron shutters, and to minor repairs. The appropriation for the work is entirely exhausted. It is proposed to extend the casemates of the water fronts of the main work so as to admit of a sufficient terreplein for heavy guns with their magazine traverses, behind earthen instead of the present stone parapets, to arrange the cover-face for additional fire, to provide splinter proof traverses in the place of arms, to place a battery on the glacis at the north end of the covered way, and to erect a new battery with magazine traverses and parados beyond the glacis.

Estimated cost of these modifications, $308,000. Appropriation asked for the next fiscal year, $160,000.

Fort at Willet's Point, eastern entrance to New York Harbor, in charge of Major H. L. Abbot, brevet brigadier general United States Army.—The funds available for this work being nearly exhausted, operations have been restricted to preparing the foundations for a large storage magazine, to fitting up a service magazine for the reception of powder, and to caring for the property on hand. The experiment of employing soldiers of the batallion of engineers upon the work has been tried to a limited extent with success. It is proposed to construct upon the bluff

an earthen barbette battery for heavy guns with the necessary magazine traverses and parados. Estimated cost of battery $180,000. Appropriation asked for the next fiscal year, $180,000.

Fort Columbus, Governor's Island, New York Harbor, in charge of Major N. Bowen, brevet colonel United States Army, and Lieutenant Colonel John Newton, brevet major general United States Army.—Operations have consisted in the repair of the glacis, the slopes, roads and banks, the drawbridge, magazines and engineer buildings, and in making a new portcullis. It is proposed to construct an earthern barbette battery for heavy guns, with its magazine traverses on the glacis of the work, at an estimated cost of $104,000.

Appropriation asked for the next fiscal year, $104,000.

Castle Williams, Governor's Island, New York Harbor, in charge of Major N. Bowen, brevet colonel United States Army, and Lieutenant Colonel John Newton, brevet major general United States Army.—The brick floors of the ground tier have been relaid, the casemates of upper tier, galleries and railings of second and third tiers, terreplein of barbette tier and magazines, repaired.

No appropriation asked for the next fiscal year.

Fort Wood, Bedloe's Island, New York Harbor, in charge of Major N. Bowen, brevet colonel United States Army, and Lieutenant Colonel John Newton, brevet major general United States Army.—The pavement of the sallyport has been relaid, and the masonry of the sea-wall pointed. It is proposed to modify the exterior earthen battery of the work for the emplacement of heavy guns with their magazine traverses, at an estimated cost of $32,000.

Appropriation asked for the next fiscal year, $32,000.

Fort Hamilton, New York Harbor, in charge of Lieutenant Colonel Jno. Newton, brevet major general United States Army.—The work during the past year has consisted in altering embrasures on the east and north fronts, pointing scarp and counterscarp walls, rebuilding a portion of counterscarp wall, filling, grading, and sodding slopes in front of same, and in making several necessary small repairs.

New Battery near Fort Hamilton, New York Harbor, in charge of Lieutenant Colonel John Newton, brevet major general United States Army.—During the year the north and south magazines have been completed, with the exception of some work at entrances; nine magazine traverses have been finished; 3,464 lineal feet of drain built; 991 lineal feet of rubble sea-wall rebuilt; 3,407 square yards of slopes repaired and sodding re-laid. It is proposed to construct an additional earthen barbette battery, with magazine traverses for heavy guns, below the channel front of Fort Hamilton, and to extend the existing battery to supply additional emplacements for guns of like caliber, at an estimated cost of $135,000.

Appropriation asked for Fort Hamilton and batteries for the next fiscal year, $92,000.

Fort Wadsworth, New York Harbor, in charge of Major Q. A. Gillmore, brevet major general United States Army.—The only operations at this work, during the past year, were the removal of three hundred and thirty cubic yards of earth, which washed down into the road from the main slope, in rear of the fort.

No appropriation asked for the next fiscal year.

Fort on site of Fort Tompkins, New York Harbor, in charge of Major Q. A. Gillmore, brevet major general United States Army.—Operations at this work were confined to the completion of the south soldiers' latrine, the construction of drains, and the general repairs upon the slopes in

front. The drain from the latrine to and through the sea-wall at Fort Wadsworth was finished, and the latrine turned over to the garrison. A twelve-inch iron pipe was placed in the slope connecting the north ditch of the work with the drain in the north cliff battery, and an experimental system of earthen drains was laid in the main slope in front of the work. It is proposed to complete the channel front of the fort with one tier of casemates, closed in front by a low masonry scarp with cover-face, and surmounted by a high earthen parapet, thus furnishing an elevated battery for heavy guns, with their magazine traverses; to construct an exterior earthen battery for heavy guns on the north glacis, and to complete the other unfinished parts of the work essentially as originally designed. Estimated cost of completion, $300,000. Appropriation asked for the next fiscal year, $60,000; in addition to which it is asked that the unexpended balance of the appropriation for new casemated battery on Staten Island be made available for this work. The amount of this balance is $239,468 25.

Battery Hudson, New York Harbor, in charge of Major Q. A. Gillmore, brevet major general United States Army.—In the past year the entire slope in rear of this battery slid into the terreplein, in consequence of heavy and continuous rains, involving considerable expense in its repair. It has been restored at a more gentle slope, which promises to be enduring; and the cesspools have been protected from the wash of the slope by surrounding them with low walls in rear. The lining of the two principal magazines with wood was commenced. It is proposed to modify the old portion of this battery, and add some new traverses, to adapt it to the emplacement of heavy guns, and to construct an earthen extension at the south end, with the requisite traverses, and a reserve magazine, at an estimated cost of $62,000.

Appropriation asked for the next fiscal year, $60,000.

New Casemated Battery on Staten Island, New York Harbor, in charge of Major Q. A. Gillmore, brevet major general United States Army.—The operations of the past year were limited to the construction of a portion of the permanent wharf adjacent to the battery, and to the care and preservation of the work. During the current fiscal year the portion commenced will be finished by filling and paving the interior and completing the road to the shore.

No appropriation asked for the next fiscal year.

North Cliff Battery, Staten Island, New York Harbor, in charge of Major Q. A. Gillmore, brevet major general United States Army.—The entrance walls of the principal magazines were slightly prolonged to adapt them to the modified slope of the earth, the terreplein and roads were partly cleared of the washings from the rear slope, and the earth filled on the parapet and parados, and the covering of magazine was completed by bringing earth from the glacis of Fort Tompkins. It is proposed to construct a new magazine and three traverses, and to make some slight modifications to adapt the battery for the emplacement of guns of the heaviest caliber, at an estimated cost of $27,000.

South Cliff Battery, Staten Island, New York Harbor, in charge of Major Q. A. Gillmore, brevet major general United States Army.—The rain storms of July and September, 1868, affected the slopes covering the principal magazines, and rendered repairs necessary. The earthwork was restored on the north magazine with a more gentle slope, and the side walls of the entrances were prolonged to correspond thereto. The earthwork of the south magazine was partially restored at the former slope, and revetted with salt marsh sods. Platform No. 5, injured in experimental firing, was repaired. It is proposed to modify this battery

by removing some of the existing platforms, and constructing additional traverses, at an estimated cost of $17,000.

Fort at Sandy Hook, New Jersey, in charge of Lieutenant Colonel John Newton, brevet major general United States Army.—The condition of the channel front remains as at the date of the last annual report. The southeast, south and southwest land fronts have been continued during the present year. The scarp of the southeast front is generally at the reference (19′ 2″) of the sills of the loop-holes—of the southwest at the reference (14′ 10″) two courses below the sills—and the (short) south front has about half the foundations and a small portion of the scarp built to the reference (7′.) During the next year it is proposed to continue operations on the land fronts.

Appropriation asked for the next fiscal year, $150,000.

Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieutenant Colonel C. S. Stewart, brevet lieutenant colonel United States Army.—No new appropriation having been made for the year, the property has been in charge of a watchman. Two shot furnaces have been removed. The covering of bridge from demilune to the main work has been renewed, and other necessary small repairs made. It is proposed to so modify the channel fronts and demilune as to furnish emplacements for a number of heavy guns, with the requisite magazines and traverses, and to construct a new earthen barbette battery south of the fort for heavy guns, with their magazine traverses, at an estimated cost, in all, of $107,000.

Appropriation asked for the next fiscal year, $107,000.

Fort Delaware, Delaware River, Delaware, in charge of Lieutenant Colonel C. S. Stewart, brevet lieutenant colonel United States Army.—Operations have been confined to repairing platforms of barbette guns; to the removal of closure-stones of sinks of casemate quarters and barracks, fronts four and five; and to minor repairs of wharves, bridges, quarters of employés, and of the river embankments. It is proposed to modify the bastions of this work, fitting them to furnish emplacements for heavy guns, with magazine traverses and thick earthen parapets.

Appropriation asked for the next fiscal year, $37,000.

Battery at Finn's Point, New Jersey.—It is proposed to construct on this point a barbette earthen battery for guns of the largest caliber, with magazine traverses, which will cross its fire with Fort Delaware in the defense of the main channel.

Appropriation asked for this purpose for the next fiscal year, $67,000.

New fort near Delaware breakwater.—A project for the occupation of this position will be prepared as soon as the board of engineers for fortifications can give the necessary attention to it.

No appropriation asked for the next fiscal year.

Fort McHenry, Baltimore Harbor, Maryland, in charge of Colonel J. H. Simpson, brevet brigadier general United States Army.—During the year the terreplein of water battery and ditch of main work were repaired, the brick hoods of magazines increased, to protect the doors from rain; defective drains in main work relaid; covering and slopes of magazines and slopes of water battery reformed, and magazines, where necessary, recovered with sods.

No appropriation asked for the next fiscal year.

Fort Carroll, Baltimore Harbor, Maryland, in charge of Colonel J. H. Simpson, brevet brigadier general United States Army.—The only work done at this fort during the year has been in repairing the temporary wharf.

No appropriation asked for the next fiscal year.

Obstructions of the Potomac.—It was not found practicable last year to

obtain the desired co-operation of the navy in making experiments upon these obstructions. The material has been examined and painted, and is now in store. Trials will be made of the serviceableness of the obstructions as soon as arrangements can be perfected for that purpose.

No appropriation asked for the next fiscal year.

Fort Monroe, Old Point Comfort, Virginia, in charge of Colonel Henry Brewerton, brevet brigadier general United States Army.—During the year a new center pintle platform, for a fifteen-inch gun, has been constructed in the salient of the left bastion of front 4. The parapet in front of this platform has been increased in thickness. A front pintle platform for a fifteen-inch gun has been constructed in the covered way. One thousand running feet of roadway, inside of the fort, has been graded and covered with six inches of clay, completing this part of the work. Seven stone crossings have been built at various points. Twenty-three hundred running feet of drains, and a cess-pool, have been constructed, to facilitate surface drainage. The brick drains of the ramps have been repaired, as have the bridges and draws where needed. The scarp and counterscarp walls, below high water, have been cleaned, and the drift sand removed from the ditch opposite fronts 5 and 6. The terreplein slopes and ramps have been repaired, from time to time, as required. In the water battery and covered way the arches of fifteen casemates have been partially uncovered, the brick work removed, and the roofs repaired. The sand in front of the battery has been removed, and the ground graded. A portion of the sustaining wall in rear of two platforms in the covered way has been taken down and rebuilt. Part of the stone revetment of the exterior slope of the covered way, opposite front 5, has been repaired, and the advanced ditch at this point cleaned out. The terreplein of the covered way has been regraded and covered with gravel for its whole length. The bridge over the sluiceway opposite front 6 has been rebuilt, and the sluice-gate taken up and repaired. The wooden revetment of the redoubt has been repaired, as have also the fences for the protection of the glacis, &c. The breakwater opposite fronts 1 and 2 has been thoroughly repaired, and a portion of it rebuilt. It is proposed to widen the terreplein, increase the thickness of the parapets of the channel fronts of the main work, lay down barbette platforms for heavy guns, construct traverses and service magazines, and remodel and finish the redoubt.

Appropriation asked for the next fiscal year, $150,000.

Artesian well, Fort Monroe, Virginia, in charge of Colonel Henry Brewerton, brevet brigadier general United States Army.—During the past year operations were continued in sinking the eight-inch pipe until the lowest section of the pipe separated from the rest. This accident occurred after the pipes had reached a depth of five hundred and seventeen feet below the surface of the parade of the fort. It having been found, upon examination, that a pipe of five and a half inches exterior diameter could be passed through the disjointed pipe, it was decided to insert within the eight-inch cast-iron pipes wrought-iron tubes of four and a half inches interior diameter, with screw ends, and five hundred and eighty-five feet of this tubing were successfully inserted. At the depth of five hundred and seventy-four feet the bottom of the clay stratum was reached, when the auger passed into a mixture of clay and sand, the latter material, as the auger descended, being nearly ninety per cent. of the whole. After passing into the sand a water-bearing stratum was reached, which yielded a limited amount of saline water, which, when left undisturbed for twenty-four hours, rose in the tubing to a height of four feet six inches above the level of the parade of the fort. It is proposed to continue the operations of the well as long as

a reasonable prospect exists of reaching pure water within a moderate depth.

Fort Wool, Hampton Roads, Virginia, in charge of Colonel Henry Brewerton, brevet brigadier general United States Army.—Operations have been confined to the construction of the magazines of the first tier. The superstructure of the magazine at the capital, including filling rooms, stairways, and passages, has been finished, and the arches turned. The first, second, third, fourth, and fifth courses of the walls of the magazine, in rear of the casemates of the west end, have been laid, as have also the greater portions of the first and second courses of the superstructure of the magazine proper, filling-rooms, and passage-ways. The foundation of the magazine and its adjuncts at the east end have been laid. It is proposed to expend the amount available in completing the magazines, &c., of the first tier, already commenced, and other portions of the work.

No appropriation asked for the next fiscal year.

North and South Carolina and Georgia.—The works for the defense of Beaufort and the mouth of the Cape Fear River, North Carolina, and the defenses of Charleston, South Carolina, and Savannah, Georgia, remain very much as they have been for several years past. Nothing beyond some clearing away of the rubbish has been undertaken at them excepting some repairs of existing platforms at Fort Pulaski. It is desirable that these defenses should be put in a better condition, as in the event of a foreign war the harbors and ports which they cover would invite the presence of the enemy and even afford him shelter and security.

Fort Pulaski, Savannah River, Georgia, in charge of Major Q. A. Gillmore, brevet major general United States Army.—During the past year operations looking to the mounting of the armament of this fort were commenced. The work consisted of brick and stone masonry, repairs to gun platforms, the taking up and resetting of traverse stones and rails to restore the proper radius and level, the thorough repair of the water battery, and the construction of six wooden platforms for 100-pounder rifles. During the current year the repairs begun will be continued to completion. The magazine in the water-battery has been put in good condition, and the thickness of its earth covering suitably increased.

No appropriation asked for the next fiscal year.

Fort Clinch, Amelia Island, Florida, in charge of Captain J. W. Barlow, brevet lieutenant colonel United States Army.—Operations have been suspended during the year except slight repairs made by the fort keeper. The work has suffered little, though a few important repairs should be made during the next fiscal year. A resumption of active operations is desirable with a view to the early completion of the fort, and for this purpose an appropriation is recommended.

Appropriation asked for the next fiscal year, $50,000.

Fort Taylor, Key West, Florida, in charge of Colonel J. H. Simpson, brevet brigadier general United States Army, and Lieutenant Colonel C. E. Blunt, brevet colonel United States Army.—The appropriation having been exhausted operations have been suspended during the year. Pintles and traverse irons for barbette platforms have been ordered and will be set this fall. No other work can be done for want of funds. For the continuation of the work on the cover-face, counterscarp, and sea-wall, and dredging in the ditch and inner channel an appropriation is required.

Appropriation asked for the next fiscal year, $100,000.

Fort Jefferson, Garden Key, Tortugas, Florida, in charge of Colonel J. H. Simpson, brevet brigadier general United States Army, and Lieutenant

Colonel C. E. Blunt, brevet colonel United States Army.—The operations of the year have been confined mainly to the interior finish of the officers' quarters and soldiers' barracks, one section of eighteen rooms in the quarters having been essentially finished. Five rooms have been plastered in the soldiers' barracks, and a great deal of flooring, furring, and other woodwork has been put in. Sections three and four of the barracks have been roofed with galvanized iron. Some work has been done in the ditch in excavating sand, setting sluice-gates, &c. The sand removed has been put outside the counterscarp, and on the parade for leveling. During the fiscal year ending June 30, 1870, the officers' quarters and soldiers' barracks will be carried as far as possible toward completion, and the barbette platforms will be put in good condition.

Appropriation asked for the next fiscal year, $85,000.

New Fort at Tortugas.—The commencement of this work will be deferred until a suitable project for the position can be prepared.

No appropriation asked for the next fiscal year.

Fort Pickens, Pensacola Harbor, Florida, in charge of Major F. E. Prime, brevet colonel United States Army, and Captain A. N. Damrell, brevet major United States Army.—During the past year the wharf and plank road to the fort have been completed; a gun platform in west bastion prepared and the gun mounted; platform for a large gun in southwest bastion partially prepared; wooden platforms for projectiles constructed; general repairs made, and railroad from central bastion to southwest bastion repaired and extended. Operations proposed for the present year comprise the removal of rubbish and repairs of cistern, casemates, and quarters.

Appropriation asked for the next fiscal year, $20,000.

Fort Barrancas and redoubt, Pensacola Harbor, Florida, in charge of Major F. E. Prime, brevet colonel United States Army, and Captain A. N. Damrell, brevet major United States Army.—During the past year the fence around the works has been completed, the bridges have been repaired, gratings and ventilators have been put in the magazines, and general repairs made in masonry and wood-work. The proposed operations for the present year are, cleaning out rubbish, adjusting slopes, and general repairs.

No appropriation asked for the next fiscal year.

Fort Morgan, eastern entrance to Mobile Bay, Alabama, in charge of Major F. E. Prime, brevet colonel United States Army, and Captain A. N. Damrell, brevet major United States Army.—During the past year the wharf has been repaired; demolition of the citadel continued; portion of the slopes graded and sodded; breakwater repaired and continued; rubbish removed from inside of work, and general repairs made. It is proposed during the present year to continue general repairs; move rubbish from inside of the work; complete the demolition of the citadel; drain the parade; repair the wharf, and build a sea-wall for the protection of the site.

Appropriation asked for the next fiscal year, $50,000.

Fort Gaines, Dauphin Island, Mobile Bay, Alabama, in charge of Major F. E. Prime, brevet colonel United States Army, and Captain A. N. Damrell, brevet major United States Army.—At this work during the last year repairs have been made of wharf, plank walks, and buildings inside of fort; slopes and ditch partially graded; two jetties and a breakwater built; cunette excavated in ditch; main drain cleaned out and extended. The proposed operations for the present year are, completing shore protection, repairing wharf, grading and grassing slopes, putting

up fence to preserve slopes from cattle and hogs, removing old earth and timber work from inside of fort, and general repairs.

Appropriation asked for the next fiscal year, $60,000.

Fort Pike, Rigolets Pass, Louisiana, in charge of Major and Brevet Brigadier General M. D. McAlester, Major and Brevet Colonel F. E. Prime, Captain G. J. Lydecker, and Captain and Brevet Major C. W. Howell.—This fort is in good condition and only in need of slight repairs, with exception of the glacis along the Rigolets. This has been greatly damaged by being partially washed away. No work was done last year. During the current year it is proposed to restore the glacis to its original condition.

No appropriation asked for the next fiscal year.

Fort Macomb, Chef Menteur Pass, Louisiana, in charge of Major and Brevet Brigadier General M. D. McAlester, Major and Brevet Colonel F. E. Prime, Captain G. J. Lydecker, and Captain and Brevet Major C. W. Howell.—The general condition of this fort is good. No work was done during the past fiscal year. It is proposed during the current fiscal year to remove the old bridges across the moat and supply their places by new ones. It is also proposed to make general repairs to the work and quarters.

No appropriation asked for the next fiscal year.

Battery Bienvenue, Lake Borgne, Louisiana, in charge of Major and Brevet Brigadier General M. D. McAlester, Major and Brevet Colonel F. E. Prime, Captain G. J. Lydecker, and Captain and Brevet Major C. W. Howell.—This work is in very bad condition; the brick work is well preserved; the stockade ruined; the bridge dilapidated; the quarters, magazine, and cisterns, require repair.

Appropriation asked for the next fiscal year, $13,400.

Fort Jackson, Mississippi River, Louisiana, in charge of Major and Brevet Brigadier General M. D. McAlester, Major and Brevet Colonel F. E. Prime, Captain G. J. Lydecker, and Captain and Brevet Major C. W. Howell.—The general condition of the work is good. During the year but little work has been done; some slight repairs and putting up new lightning rods over magazines being all. During the next year it is proposed to erect a storage magazine and thoroughly repair the masonry, drains, and slopes of the fort and outworks, and make slight repairs to engineer buildings.

Appropriation asked for the next fiscal year, $76,000.

Fort St. Philip, Mississippi River, Louisiana, in charge of Major and Brevet Brigadier General M. D. McAlester, Major and Brevet Colonel F. E. Prime, Captain G. J. Lydecker, and Captain and Brevet Major C. W. Howell.—This work is in serviceable condition. The magazines are subject to overflow at extraordinary high water of the Gulf. No work, with the exception of slight repairs, was done during the past fiscal year. During the current fiscal year it is proposed to modify and repair the service magazine in the upper battery; to make general repairs, and to construct a storage magazine with service magazines in connection therewith.

Appropriation asked for the next fiscal year, $110,000.

Fort Livingston, Barataria Bay, Louisiana, in charge of Major and Brevet Brigadier General M. D. McAlester, Major and Brevet Colonel F. E. Prime, Captain G. J. Lydecker, and Captain and Brevet Major C. W. Howell.—The general condition of the work is fair. No work was done during the past year and none is at present contemplated during the current year.

No appropriation asked for the next fiscal year.

Fort at Fort Point, entrance to San Francisco Harbor, California, in charge of Major George H. Elliot.—The sea-wall, six hundred feet long, designed to protect the proposed eastern barbette battery, was completed during the last winter. The ground in rear of this wall has been filled flush with the coping, and a pavement of dry stones has been laid for a distance of thirty feet in rear of the wall. The pile wharf, the roadways, the quarters, stables, and storehouses, have been kept in repair. The iron work of the embrasures, the railings and stairways have been scraped clean of rust and have been painted. A thorough repair of quarters for officers and men has been undertaken and will be finished early in the present fiscal year. An apron of masses of rock, from ten to fifteen tons weight, has been commenced in front of the channel sides of the fort to prevent the wearing of the beach. A series of experiments with the cements and limes obtainable on the Pacific coast, and with the building sands obtained in San Francisco Harbor, has been commenced.

Appropriation asked for the next fiscal year, $200,000.

Fort at Lime Point, San Francisco Harbor, California, in charge of Major George H. Mendell, brevet colonel United States Army.—During the fiscal year two large blasts have been exploded at Lime Point. The first took place on the 24th October, 1868, and contained nearly twenty four thousand pounds of mortar and cannon powder. The second, of sixteen thousand five hundred pounds of powder, in three charges, was exploded on the 17th April. The gross effect of these two explosions was the removal of about ninety thousand cubic yards of rock. A tunnel with two chambers, of capacity of six thousand pounds each, is ready for loading. Seventy-five thousand cubic yards of rock have been removed from the site during the year, to an average distance of eighty feet. Operations were suspended during four months out of the twelve. The fence, three miles in length, separating the public land from that adjoining, which was commenced in the previous fiscal year, was finished in July. During the next year it is proposed to continue the rock excavation, construct a battery on Point Cavallo, and emplacements for guns and mortars on the hills above Lime Point, with the necessary roads.

Appropriation asked for the next fiscal year, $200,000.

Fortifications at Alcatraz Island, San Francisco Harbor, California, in charge of Major George H. Elliot, brevet colonel United States Army.—Operations during the past year have consisted in excavating the rocky slopes in rear of batteries 2 and 3; in repairing public property; painting the magazine roofs, the schooner, and the office, and in other miscellaneous work. About four thousand yards of rock have been excavated and thrown over the scarp walls. The earthy product of the excavation is saved for future use. It is proposed to remove the ridge of the island, leveling it to a plane; give the necessary increase of thickness to the parapets, and introduce additional traverses with magazines and bomb-proofs.

Appropriation asked for the next fiscal year, $100,000.

Defenses at the mouth of the Columbia River, Oregon, in charge of Major George H. Mendell, brevet colonel United States Army.—During the year extensive repairs were made on Fort Stevens. The scarp revetment, which was much decayed, was removed, and the exterior slope of the parapet extended to the bottom of the ditch. It was faced with plank to protect the lower part of the slope from washing where it is reached by the water of the ditch. A covered way with parapet arranged for infantry fire was constructed along the counterscarp. The wooden

magazines at Cape Disappointment exhibit signs of decay. Arrangements have been made to construct a fire-proof powder-house for storage of powder. The condition of the works both at Fort Stevens and Cape Disappointment is good.

No appropriation asked for the next fiscal year.

BATTALION OF ENGINEERS AND DEPOTS.

Battalion of engineers, commanded by Major Henry L. Abbot, brevet brigadier general United States Army, headquarters Willet's Point, New York Harbor.—The strength of the five companies constituting the battalion of engineers, on the 30th of June, 1869, was 23 officers and 634 enlisted men. 116 recruits were needed to complete the organization. The companies of the battalion were stationed and commanded as follows: At Willet's Point, New York Harbor, company A, Captain A. Mackenzie; company B, Captain A. H. Burnham, brevet major United States Army; company C, Captain O. H. Ernst. At Yerba Buena Island, California, company D. Captain S. M. Mansfield, brevet lieutenant colonel United States Army. At Jefferson Barracks, Missouri, company E, Captain P. C. Hains, brevet lieutenant colonel United States Army.

A detachment from companies A, B, C, and E, under the command of First Lieutenant C. B. Sears, served at the United States Military Academy for the purpose of aiding in the instruction in practical engineering. A detachment of 38 men, under the command of First Lieutenant Thomas Turtle, were engaged from April, 1869, upon the survey of the battle field of Gettysburg; and small detachments were made from time to time from the post in the west for other duties.

The troops at the several posts have been carefully instructed in the infantry tactics, both practically and theoretically, and in the drills peculiar to their special arm of the service, and have accomplished a large amount of work in the construction of the buildings and preparation of the grounds at the depots established for them. Theoretical instruction for the men, as directed in General Orders No. 56, of 1866, has been continued, with considerable interest manifested, and encouraging progress made; and the original intention of making the service with the battalion a school of practice for the officers on duty with it has been kept steadily in view in the methods of instruction marked out. With the sanction of the Secretary of War the duty of experimentally developing a torpedo system as an accessory of the permanent sea-coast defenses was devolved upon the battalion of engineers, under the direction of the board of engineers for fortifications, by instructions from this office in May last.

I would again recommend that two principal musicians should be allowed to the non-commissioned staff of the battalion; that the seventh section of the act of July 13, 1866, taking from engineer soldiers the per diem paid to other soldiers, when engaged on continuous labor, should be repealed; because the effect of this law is to make the pay of engineer soldiers much less than that given to other troops when engaged on extra duty, works an injustice to the men, and excludes a class of recruits from their ranks which the interests of this special arm of the service requires should be enlisted. With this law repealed, the engineer soldier will be replaced upon the same footing as the other troops of the service. I would also renew my recommendation that an appropriation of $1,000 be made to purchase the stock out of which siege and trench materials are fabricated for the instruction of the troops at Willet's Point.

Engineer post and depot at Willet's Point, New York Harbor, commanded by Major Henry L. Abbot, brevet brigadier general United States Army.—This point was selected in 1865 as the headquarters of the battalion of engineers, and as the depot for the storage of the engineer material used on the Atlantic seaboard. The property is stored in one large shed, 250 feet long by 37 feet wide, constructed for the purpose, and in eight temporary buildings made for the Grant General Hospital in the late war. The tools are sold for use on the different works in charge of officers of the corps as called for. The larger part of the bridge equipage of the army is preserved at this place, from which other depots are supplied, according to the necessities of the service.

Since the date of my last report the permanent hospital then under construction, with funds furnished by the Quartermaster's Department, has been completed, excepting the plumbing; and an old building has been remodelled, for officer's quarters, by the labor of the garrison, and with funds furnished by the same department.

Much has been done at the depot during the past year in preparing experimental carriages, &c., for the board of engineers convened to report upon the military bridge equipage of the army.

An appropriation of $45,000 is recommended for the erection of permanent barracks for officers and men, which are much needed, the old temporary buildings used for quarters and barracks having gone very much to decay.

Engineer post and depot at Jefferson Barracks, Missouri, commanded by Captain P. C. Hains, brevet lieutenant colonel United States Army.—During the past year the work of altering and repairing the north row of soldiers' quarters, with a view to making storehouses for engineer property, has been carried out, the buildings nearly finished, and most of the material of the post carefully stored away in them.

The work of fitting the bridge train has been commenced and is well advanced.

The work of preparing the quarters for the command is progressing satisfactorily; about one half of the fence at the northern boundary has been put up, the finishing of the entire inclosure of the engineer reservation being delayed only to determine accurately the position of the line of the west boundary.

The post of Jefferson Barracks was transferred to the corps of engineers, under the operation of General Orders No. 9, dated headquarters military division of the Missouri, October 21, 1867, and the agreement to pay to the Quartermaster's Department $20,000 for the property. As by the act of March 2, 1867, but one-half of the sum appropriated for the quarters at Jefferson Barracks could be expended, a further appropriation of $10,000 is necessary to complete the agreement with the Quartermaster's Department. For the construction of four cisterns to hold drinking water for the command a sum of $1,000 is necessary.

The appropriation of the several amounts named is recommended.

Engineer post and depot, Yerba Buena Island, California, commanded by Captain S. M. Mansfield, brevet lieutenant colonel United States Army.—At the date of my last report, little had been done toward the establishment of this depot, and the command was encamped upon the island.

At the close of the fiscal year there had been constructed, almost exclusively by the labors of the garrison, the necessary barracks for officers and men, a guard-house, hospital, and quarters for laundresses. A substantial wharf, 325 feet in length, was also built; with a view of obtaining a supply of drinking water, a tunnel 178 feet in length had been driven into the side of the hill, and it is expected a good supply will be obtained after driving it a short distance further.

A canvas pontoon train, with a supply of engineer tools, had been received. A military survey of the island by the garrison, for the purpose of fortifications, was well advanced, under the immediate instructions of the board of engineers for the Pacific coast.

RIVER AND HARBOR IMPROVEMENTS.

The balances of the appropriations for the improvement of rivers and harbors, approved June 23, 1866, and March 2, 1867, remaining on hand July 1, 1868, have been applied to continuing the works of improvement referred to in the last annual report.

The appropriation of $1,500,000, approved July 25, 1868, for the "repair, preservation, extension, and completion of certain public works on rivers and harbors," &c., was distributed with the sanction of the Secretary of War.

In addition to the list of works specified in my report of October 20, 1868, there has been allotted from this appropriation, as follows: Harbor at mouth of Genesee River, $1,100; harbor at Saugatuck, Michigan, $23,900; which absorb the entire appropriation.

The officers in charge of the works were notified of the respective allotments, and were directed to apply the moneys thus appropriated to carrying on the improvements in accordance with the approved and authorized plans.

By an act approved April 10, 1869, two millions of dollars were appropriated for "the fiscal year ending June 30, 1869, and the year ending June 30, 1870, to be expended for the repair, extension, preservation and completion of works for the improvement of rivers and harbors, under the direction of the Secretary of War," &c. This sum has been distributed as follows:

Superior City Harbor	$44, 550 00
Marquette Harbor	26, 730 00
Green Bay Harbor	44, 550 00
Manitowoc Harbor	17, 820 00
Milwaukee Harbor	35, 640 00
Racine Harbor	22, 275 00
Kenosha Harbor	5, 346 00
Chicago Harbor	29, 700 00
Michigan City Harbor	31, 185 00
Saugatuck Harbor	6, 039 00
White River Harbor	44, 550 00
Pentwater Harbor	17, 820 00
Père Marquette Harbor	31, 185 00
Aux Becs Scies Harbor	29, 318 85
Cleveland Harbor	13, 380 00
Conneaut Harbor	8, 910 00
Erie Harbor	22, 275 00
Buffalo Harbor	89, 100 00
Oswego Harbor	22, 275 00
Boston Harbor	82, 170 00
Provincetown Harbor	8, 910 00
Sheboygan Harbor	14, 850 00
Au Sable Harbor	2, 970 00
Grand Haven Harbor	1, 866 15
St. Mary's River	10, 692 00
Kennebec River	14, 850 00
Saco River	22, 275 00
Hudson River	89, 100 00

Willamette River	$13,365 00
Tennessee River	40,095 00
Upper Mississippi River	35,640 00
Mouth of Mississippi River	64,350 00
Susquehanna River	990 00
Patapsco River	26,730 00
Illinois River	84,150 00
Genesee River	1,000 00
East River	178,200 00
Great Brewster Island	24,750 00
St. Clair Flats	142,560 00
Falls of the Ohio	178,200 00
Des Moines Rapids	178,200 00
Rock Island Rapids	133,650 00
Little Sodus Bay	1,000 00
Maumee Bay	29,700 00
Blossom Rock	29,700 00

A summary is submitted herewith, showing the progress made at each of the localities on the works of improvement; amounts of money expended during the fiscal year; amounts available July 1, 1869, for each work, from the several appropriations and allotments; and amounts required to be appropriated, which can be profitably expended during the next fiscal year.

An accompanying appendix contains the reports of the engineers in charge of the improvements.

HARBORS ON LAKE SUPERIOR, AND ON THE WEST AND SOUTH SHORES OF LAKE MICHIGAN.

Officer in charge, Brevet Colonel J. B. Wheeler, Major corps of engineers, having under his orders the following officers:

Captain D. P. Heap, corps of engineers, special superintendent for the harbors of Kenosha, Chicago, Michigan City, and New Buffalo; station, Chicago.

Captain J. W. Cuyler, corps of engineers, special superintendent of the harbors of Superior City, Ontonagon, and Eagle Harbor; station, Ontonagon.

Assistant, W. H. Hearding, special superintendent for the harbors of Marquette, Green Bay, Manitowoc, Sheboygan, Milwaukee, and Racine; station, Milwaukee.

Assistant, W. T. Casgrain, in charge of surveys and preparation of maps and other duties connected with surveys of harbors; station, Milwaukee.—(See Appendix A.)

1. *Superior City Harbor, Wisconsin—Lake Superior.*—Under the appropriation of 1867 the pier was commenced, starting from Minnesota Point; 768 running feet were built during the fiscal year ending June 30, 1868. During the remainder of 1868, 320 running feet of pier were added, making a pier about 1,100 feet long. The payments for the work exhausted the appropriation. In May, 1869, an allotment of $45,000 was made to be expended upon this harbor. The work was put under contract without delay, and on the 15th of June the first crib on the eastern side was placed, forming the beginning of the pier from Wisconsin Point. A wing dam 178 feet long, of timber filled with brush, slabs, and stone, was built, connecting this crib with the shore. This structure is intended to prevent the current from passing between the crib and Wisconsin Point, and make it flow out between the piers. The little work already

done has had a very beneficial effect upon the channel, both in deepening and straightening it, especially over the outside bar. The work should not be allowed to remain in an unfinished condition.

Appropriated for the improvement of this harbor in 1867.	$63,000 00
Allotted from appropriation of 1869	45,000 00
Total	108,000 00
Of which amount there was unexpended on June 30, 1869.	$45,712 85
Amount estimated for completion	155,300 00
Amount required for next fiscal year	75,000 00

2. *Ontonagon Harbor, Michigan—Lake Superior.*—The last annual report stated that 449 running feet of pier had been built during the fiscal year ending June 30, 1868. Since that time the pier has been extended 900 feet, making 1,350 feet of pier on the eastern side; 455 piles that obstructed the entrance have been removed, and 270 feet of the western pier repaired and built up. There still remain not less than two, and probably five, sunken cribs in the harbor that must be removed in order to give a safe entrance to vessels sailing to and from this p ace. A contract has been made with E. F. Prince to remove these cribs for the sum of $3,000, but this work is not begun, as the unexpended balance is required for repairing the west pier and deepening the channel.

There was appropriated in 1867 for the improvement of this harbor	$97,600 00
Of which amount there was on hand June 30, 1869	9,731 94
Amount estimated for completion	238,780 00
Amount required for next fiscal year	80,000 00

3. *Eagle Harbor, Michigan—Lake Superior.*—A contract was made on the 10th of August, 1867, with David Quinn, of Chicago, to remove this rock at the rate of fifty-eight dollars ($58) per cubic yard, the work to be completed on the 1st of October, 1868. Mr. Quinn failed in his work. A special report, giving all the facts in the case, will be found in Appendix A 1. After due notice given a contract was made on the 26th of January, 1869, with George W. Townsend, of Boston, for removing this rock at the rate of forty dollars ($40) per cubic yard. Work was commenced early in June, and during that month seventy-three cubic yards were removed. The contractor was sanguine of success and hoped to make rapid progress towards completion this season.

There was appropriated in 1867	$65,000 00
Of which amount there was on hand on the 30th of June, 1869	44,253 33
Amount estimated for removal of rock alone, (see report of 1868)	195,588 00
Amount required for next fiscal year	100,000 00

4. *Marquette Harbor, Michigan—Lake Superior.*—There had been finished on the 30th of June, 1868, the date of the last annual report, 310 running feet of breakwater. During the past fiscal year 450 feet have been built, making 760 feet in all. This amount being all that was required of the contractor, the work was re-advertised and let to the lowest bidder, viz: Hart & Jennings, of New York, who are under bonds to build not less

than 200 feet during the present season. This will make 960 feet, or nearly one-half of the proposed work. The effect of this breakwater is sensibly felt in heavy weather, and it is to be hoped that greater efficiency may be given by adding to the pier during the year 1870.

There was appropriated in 1867	$85,000 00
There was allotted from the appropriation of 1869	27,000 00
Total	112,000 00
Of which amount there was unexpended on June 30, 1869	$56,074 05
Amount estimated for completion	273,130 00
Amount required for next fiscal year	91,000 00

5. *Green Bay Harbor, Wisconsin—Lake Michigan.*—The work of the past season has been entirely confined to excavating the new cut, and the amount of material removed, measured in scows, during the fiscal year ending June 30, 1869, numbers 77,822 cubic yards. A second dredging machine has been hired to begin work by the middle of August, 1869. The two machines, with favorable weather, should be able to finish the cut this season. Contracts were made with Smoke & Schuette, of Manitowoc, who were the lowest bidders, for protecting the cut through Grass Island by close piling. It is proposed to build about 600 feet of this protection work this season and notice the results. It may be possible, judging from the action of the water during the past two years, that no further protection will be required. If such should not be the case the estimate for completion must be increased in amount.

There was appropriated for the improvement of this harbor in 1866	$30,500 00
Appropriated in 1867	45,000 00
Allotted from appropriation of 1868	17,500 00
Allotted from appropriation of 1869	45,000 00
Total	138,000 00
Of which there was unexpended on the 30th of June, 1869	$56,526 87
Original estimate of completion	155,416 77
Required for completion and for the next fiscal year	17,500 00

6. *Manitowoc Harbor, Wisconsin—Lake Michigan.*—On the 30th of June, 1868, the condition of the work done was as follows: 866 lineal feet of pier on the north side in a finished state, 416 feet of pier on south side built to the surface of the water, and 130 feet of close piling forming a connection with the shore and inner end of north pier. During the fiscal year ending June 30, 1869, 64 feet were added to the north pier, 320 feet added to the south pier, the pier built to the surface of the water, as reported, was finished, and 33,064 cubic yards of material removed from the channel. The whole pier work on the 30th of June, 1869, is as follows:

New work on north side, running feet	864
Repairs of old work, north side, running feet	66
Close piling, joining the shore, running feet	130
New work on south side, running feet	736
Total running feet	1,796

Contracts have been made for prosecuting the work vigorously to the extent of the means in hand, and 64 feet of pier, built to the water's surface, have been added to the south pier. It is expected that 200 feet will be added to this pier this season, and that the channel will be opened to the depth of 12 feet.

There was appropriated for the use of this harbor in 1866.	$52,000 00
Appropriated in 1867	45,000 00
Allotted from appropriation of 1868	17,500 00
Allotted from appropriation of 1869	18,000 00
Total	132,500 00
Of which there was unexpended June 30, 1869	$20,261 65
Original estimate of completion	141,747 82

In this estimate the amount for dredging was too small, and no allowance was made for repairs upon the old work that had to be made in order to secure the new work. Supplying this deficiency the estimate of the amount for completion and required for use during the next fiscal year should be $31,000.

7. *Sheboygan Harbor, Wisconsin—Lake Michigan.*—The work of 1868 was confined to supplying the ballast that had settled in the cribs and dredging in the channel between the piers and entrance to the harbor, amounting to 148½ cords of stone for the cribs, and removing 9,034 yards of earth and sand from the channel. A contract has been made with H. Barrett, of Sheboygan, to place this season not less than five cribs in extension of south pier. This will be done unless prevented by causes not now foreseen.

There was appropriated in 1866	$47,598 91
There was appropriated in 1867	8,000 00
Allotted from appropriation of 1869	15,000 00
Total	70,598 91
Of which there was unexpended on the 30th of June, 1869.	$18,051 13
Amount of estimate in 1868	49,000 00
Amount required for next fiscal year to complete the work recommended	34,000 00

8. *Milwaukee Harbor, Wisconsin—Lake Michigan.*—During the past year 200 running feet of pier work was added to the north pier and 100 feet to the south, making 300 feet in all. Two dredging-machines were employed in the fall of 1868 to deepen the channel over the bar at the entrance, being employed thirty-five days. This season the city authorities have employed the dredges to continue the work and also to dredge between the piers. It is proposed to add 50 feet to the north pier and 150 feet to the south pier, 200 feet in all, this season. This can be built with the balance on hand. This harbor was mainly built by the city authorities during the years 1854, 1855, 1856, and 1857, and the necessity for a renewal of a great portion of the structure above water, at no far

distant day, is apparent. In the following estimates $10,000 are included for this purpose:

There was appropriated for the improvement of this harbor in 1866	$48,283 51
Allotted from appropriation of 1869	36,000 00
Total	84,283 51
Of which amount there was unexpended on June 30, 1869	$51,774 08

The amount required to complete the improvement recommended in previous report	$44,000 00
For repairs of old work	10,000 00
Required for next fiscal year	54,000 00

9. *Racine Harbor, Wisconsin—Lake Michigan.*—During the fiscal year 96 feet were added to the north pier, and the entire north pier, left unfinished, was built up. Work was commenced this season to repair the old south pier and dredge the channel between the piers. These repairs consist in tearing away the rotten timbers above the surface of the water, replacing them by new ones, and sheath-piling the outside of each crib to prevent the flow of sand through the intervals into the harbor. This will be completed this season, and if the south pier could be carried out as far as the north pier there is reason to believe this harbor would remain in good condition until the lake-drift or accretion again becomes troublesome.

There was appropriated for the improvement of this harbor in 1866	$23,910 00
Appropriated in 1867	45,000 00
Allotted from the appropriation of 1869	22,500 00
Total	91,410 00
Of which amount there was unexpended on the 30th June, 1869	$27,059 89
Amount required for completion	40,000 00

Which could be used next fiscal year. This estimate of completion is to carry out the south pier equal in length to the north pier.

10. *Kenosha Harbor, Wisconsin—Lake Michigan.*—The engineer in charge does not recommend a further extension of the piers for this harbor, and makes no estimate for this purpose. An estimate of $20,000 for repairs of old work and $35,000 for dredging was made in the annual report of 1867. This recommendation is renewed, and the amount required for the next fiscal year is $40,000. The end crib of north pier, after being placed in 1867 and accepted, was moved from its position during a heavy gale. Before paying the contractors in full they were required to build this up so as to have the surface on the same level with the remainder of the pier. This they did in the past fiscal year by driving piles, joining the displaced crib and the main pier, and building on the piles a superstructure conforming in general appearance to the rest of the work. The ice and waves carried this additional work away during the past winter. It is now proposed to take out the stone, lift the crib from its present bed, and, if it be uninjured, to replace it in its original position; if it cannot be replaced, to remove it entirely, or enough of it so that it shall present no obstruction to navigation. This will be done

this season, and will form the principal work of the year. The timber-work above the water of the old south pier is all very much decayed, and unless repaired during the next season will be leveled to the surface by the water.

There was appropriated for this harbor in 1866	$75,461 41
Allotted from appropriation of 1869	5,400 00
Total	80,861 41
Of which there was unexpended on the 30th June, 1869...	$5,890 81

This amount will be expended during the present season.

11. *Chicago Harbor, Illinois—Lake Michigan.*—The building of the south pier and its extension as far as the light-house pier, a distance of 610 feet, has been contracted for, and the greater portion of it will be done this season. This extension should be carried on until the south pier is equal in length to the north pier. This will require the construction of 600 feet of pier-work, that may be composed of cribs 20 feet wide for 500 feet, and the remaining 100 feet of cribs 25 feet wide, filled with stone. The cost of this 600 feet may be estimated at $70 per running foot, or for the entire addition, $42,000. Adding $3,000 for superintendence, there will be required for the next fiscal year $45,000. During the fiscal year the north pier was fully completed; the end of pier being in water 23 feet deep. It has been considered advisable to protect the head of the pier by covering the end with 12-inch square timbers firmly bolted to the end of pier, filling up the cribs with stone, covering the pier with a coating of coal-tar, and driving seven clumps of fender-piles around the end of pier. This work, with the work of building the south pier for at least 600 feet, will form the probable progress for the season. Surveys have been made and projects are being prepared with a view to affording greater safety to the commerce of this important harbor.

There was appropriated for this harbor in 1866	$88,704 00
Allotted from the appropriation of 1868	35,000 00
Allotted from the appropriation of 1869	30,000 00
Total	153,704 00
Of which there was expended on June 30, 1869	$66,869 57

12. *Michigan City Harbor, Indiana—Lake Michigan.*—During the fiscal year ending June 30, 1869, 352 feet of pier have been built, 708 feet of sheath-piling constructed, and 111,080 cubic yards of earth removed by dredging. Of this 352 feet 96 feet were added to the eastern pier and 256 to the western. It is proposed during the present season to finish the sheath-piling recommended in previous reports, build not less than 288 feet of pier, and continue the dredging. This will more than complete the work recommended excepting the pier work. In the original recommendation the length of piers was based upon the amount of money appropriated, and it was proposed to add 288 feet to the eastern and 320 to the western pier. With the means now available 242 feet can be added to the eastern pier and 498 feet to the western. These additions bring out the piers nearly equal in length, give a depth of 12 feet at the entrance, and form, in the aggregate, more pier work than was recommended. Experience at this place has shown that the extension of the western pier was of more importance, even, than carrying out the east-

ern one, and has led to reducing the length of one and adding to the other. A further extension of piers might be advantageous, but no recommendation for this project is made at the present time.

There was appropriated for this harbor in 1866	$75,000 00
Allotted from appropriation of 1868	25,000 00
Allotted from appropriation of 1869	31,500 00
Total	131,500 00
Of which there was unexpended on the 30th June, 1869...	$57,422 12

13. *New Buffalo Harbor, Michigan—Lake Michigan.*—The work during the fiscal year was devoted to opening a new cut through to Lake Michigan and close-piling the sides of this channel. Although successful in carrying the cut through from Lake Pottawatomie into Lake Michigan, the action of the waves of the latter lake was such as to close it up by the drift of sand. This was done several times. It is proposed to make a dam across the mouth or near the outlet of the Galien River and force this stream to go through the new cut. This will be done this season, and work will be suspended to notice its action and watch the results.

There was appropriated in 1867........................	$60,000 00
Of which there was unexpended on June 30, 1869........	7,161 50

14. *Survey of the harbor of Charlevoix, Michigan, Lake Michigan.*—In compliance with the request of the Hon. T. W. Ferry, member of Congress, and with the approbation of the honorable Secretary of War, a survey of the harbor of Charlevoix, Michigan, has been made, with a plan for its improvement and estimate of the cost, &c. The estimated cost of the improvement of the harbor is, in round numbers, $200,000, and Colonel Wheeler, to whom this duty was intrusted, remarks "that from the location of the harbor and the width of the channel that we are obliged to adopt in improving it, I am of the opinion that the interests of commerce do not require this place to be made a harbor of refuge." These views are concurred in. (See Appendix A 2.)

15. *Resurvey of Port Washington, Wisconsin, Lake Michigan.*—The officer in charge of harbor works in the district in which this locality lies has been directed to make the re-survey called for by resolution of the Committee of Commerce of the House of Representatives, and report a plan for its improvement with estimate of cost. This report has not been received.

16. *Harbor of Du Luth, Lake Superior*—The survey of this harbor was placed in the charge of Brevet Colonel J. B. Wheeler, corps of engineers, and has been completed. He is now engaged upon the reduction of the notes of the survey, and in the preparation of his report.

HARBORS ON THE EASTERN SHORE OF LAKE MICHIGAN.

Officer in charge, Brevet Colonel F. U. Farquhar, captain corps of engineers, with the following assistants:

Lieutenant E. A. Woodruff, corps of engineers, special superintendent for the harbors of Aux Becs Scies, Manistee, Père Marquette, and Pentwater station, Milwaukee.

Assistant J. F. Saunders, special superintendent for the harbor at White River.

Assistant Alfred Noble, special superintendent for the harbors of Muskegon, Grand Haven, Black Lake, Saugatuck, and South Haven; station, Milwaukee. (See Appendix B and B 14.)

1. *Aux Becs Scies Harbor, Michigan, (Frankfort.)*—Owing to the lateness of the commencement of the present season for work, but little progress had been made up to the end of the fiscal year. A contract for dredging has been entered into, and during the present working season it is expected that the channel between the piers will be dredged to a depth of 10 feet, and that the north pier will be extended 320 feet.

Amount on hand July 1, 1868	$31,481 82
Allotted from appropriation of 1868	10,000 00
Allotted from appropriation of 1869	31,500 00
	72,981 82
Expended during the fiscal year	$33,836 39
Balance on hand July 1, 1869	39,145 13

To make this a good harbor of refuge, both piers should be extended to the depth of 12 feet in the lake, and the channel dredged to a depth of 14 feet, which would cost $60,000. This amount can be profitably spent during the fiscal year ending June 30, 1871. (See Appendix B 1.)

2. *Manistee Harbor, Michigan.*—During the last fiscal year the south pier was extended 256 feet, and the north pier 96 feet. It is expected that the north pier will be extended 160 feet, and the south pier 96 feet during the present season. To complete the improvement of this harbor both piers should be extended, the north, 512 feet, and the south, pier 608 feet beyond the extension likely to be made during this season's work, which would cost $70,000. The sharp angle on the south side of the channel should be cut away and the channel bank revetted, at a cost of $9,000.

Amount on hand July 1, 1868	$25,002 04
Expended during the fiscal year	14,439 29
Balance on hand July 1, 1869	10,562 75

There can be profitably expended during the fiscal year ending June 30, 1871	70,000,00.

(See Appendix B 2.)

3. *Père Marquette Harbor, Michigan.*—The work of the fiscal year consisted in extending the north pier 128 feet, and in completing the superstructure of the south pier. During the present working season it is proposed to carry out the north pier 384 feet, which will exhaust the balance on hand for the improvement of this harbor.

Amount on hand July 1, 1868	$8,979 23
Allotted from appropriation of 1869	31,500 00
	40,479 23
Expended during the fiscal year	7,888 97
Balance on hand July 1, 1869	32,596 26

To remove the old slab pier on the south side of the harbor, and to dredge in and beyond the space it occupies, will cost $52,000, which can be profitably expended during the fiscal year ending June 30, 1871. (See Appendix B 3.)

4. *Pentwater Harbor, Michigan.*—The work done during the past fiscal year was the extending of the south pier 256 feet, and dredging 22,632 cubic yards of earth from between the piers. Owing to the want of a pier on the north side of the channel, it filled up during the winter, so that in the spring there was only a depth of six feet where ten feet was reported last autumn. The residents have, at their own expense, dredged the channel to the former depth of 10 feet, and a north pier is now being built. During the gales of last autumn and winter, the south pier suffered severely. The superstructure, for 32 feet from the outer end of the pier, was carried away, and the adjoining superstructure was much damaged. The whole pier has considerably settled, and will require much work to repair it. These necessary repairs, together with the building of 600 feet of pier on the north side of the channel, are expected to be completed this working season, and will exhaust the balance on hand applicable to the harbor. To complete the improvement of this harbor, the south side of the entrance where the revetment is of slabs should be dredged away; for this it is estimated that the sum of $40,000 will be required.

Amount on hand July 1, 1868	$29,946 88
Allotted from appropriation of 1869	18,000 00
	47,946 88
Expended during the fiscal year	22,649 33
Balance on hand July 1, 1869	25,297 55
Amount required for the fiscal year ending June 30, 1871.	$40,000 00

(See Appendix B 4.)

5. *Mouth of White River, Michigan.*—This harbor is reported to be in bad condition. During the past winter much of the new channel has been filled up. None but vessels drawing less than six feet water can now enter White Lake. It is expected that during this season's work the channel will be dredged to a depth of 10 feet, and a pier carried out for its protection as far as the 6-feet curve. Early next spring the pier can be further extended as far as the 12-feet curve. Should the weather be favorable the north pier may be extended to the 12-feet curve this autumn. The balance remaining on hand applicable to this harbor will be exhausted during the present fiscal year. To give a channel at least 12 feet deep, and to extend the piers to 15 feet of water in the lake, will require an additional sum of $50,000, which can be profitably expended during the fiscal year ending June 30, 1871.

Amount on hand July 1, 1868	$18,880 28
Allotted from appropriation of 1869	45,000 00
	63,880 28
Expended during the fiscal year	12 206 50
Balance on hand July 1, 1869	51 673 77

(See Appendix B 5.)

6. *Muskegon Harbor, Michigan.*—Two cribs (32′ × 20′) have been placed on the extension of the north pier, and one (32′ × 32′) on the end of the south pier, and the superstructure on both piers completed. During the present working season the north pier will be extended 320 feet, and the south pier will be filled with stone ballast. It will be necessary to repair the slab work in the interior of the crib pier, to do which the slabs should be removed to one foot below the water surface, and a crib superstructure should be built at a cost of $28,000. Unless this is done there will be danger from breaches and the consequent filling up of the channel between the piers. Before a further extension of the piers into the lake, the effects of the present season's work should be observed.

Amount on hand July 1, 1868	$28,484 41
Expended during the fiscal year	12,171 45
Balance on hand July 1, 1869	16,312 96
Additional amount required for completion	$63,450 00
Required for the fiscal year ending June 30, 1871	30,000 00

(See Appendix B 6.)

7. *Grand Haven Harbor, Michigan.*—The pier on the south side of the channel has been extended 100 feet, and the old pile work interior to that part of the same pier, which was repaired in 1866, has been repaired for a length of 465 feet. To complete the improvement of the harbor, a pier on the north side of the entrance to the river is necessary, and the repairs to the old pile pier should be continued for an additional length of 600 feet. The necessity for a north pier has been fully set forth in previous reports. It should be 1,700 feet long, and would cost $200,000, and the repairs of the old south pier, $14,000. This harbor is one of the most important of those on the east shore of Lake Michigan, and is by far the best. When once the proposed improvements are completed, it will be a long time before a further outlay will be required.

Amount on hand July 1, 1868	$30,295 61
Expended during the fiscal year	27,048 69
Balance on hand July 1, 1869	3,246 92
Amount required for completion	$200,000 00
Required for the fiscal year ending June 30, 1871	100,000 00

(See Appendix B 7.)

8. *Black Lake Harbor, Michigan.*—During the present fiscal year five cribs (32′ × 20′) have been placed on the line of the south pier, extending it 160 feet, and one crib on the north pier, and the superstructure finished. The south pier settled very irregularly during the winter, and the outer crib was moved from its place. In accordance with the recommendation of a board of engineer officers assembled in May last, for the consideration of certain harbor structures in Lake Michigan, the following work will be done during the present working season for the improvement of this harbor. An enrockment will be placed along the side of the south pier to prevent a further scouring out of the sand. The south pier will be repaired, a crib superstructure will be built to prevent a breach between the crib work and the shore, and a pile revetment will be built at the head of the cut, to prevent the stream from washing out

the sand and depositing it on the outer bar. In addition, the point at the head of the cut should be dredged away in order to straighten the channel, which, together with the necessary revetment, will require an additional appropriation of $10,000.

Amount on hand July 1, 1868	$46,648 92
Expended during the fiscal year	22,160 30
Balance on hand July 1, 1869	24,488 62
Amount required for completion	$10,000 00
Required for the fiscal year ending June 30, 1871	10,000 00

(See Appendix B 8 and B 12.)

9. *Saugatuck Harbor, Michigan, (Mouth of Kalamazoo River.)*—Nothing was done at this harbor during the fiscal year. In the present working season it is proposed to revet the left bank of the river for a distance of 2,700 feet, as recommended by a board of engineer officers convened for the consideration of the project for this harbor. The present piers at the mouth of the river were built by the local authorities, and they have contracted the stream so much that at high water in the river the piers are much endangered. To obviate this it is proposed to build a north pier and interior revetment, and to remove the present slab revetment. These improvements would cost $75,000.

Allotted from appropriation of 1868	$23,900 00
Allotted from appropriation of 1869	6,100 00
	30,000 00
Additional amount required, and which can be profitably expended during the fiscal year ending June 30, 1871	$75,000 00

(See Appendix B 9 and B 13.)

10. *South Haven Harbor, Michigan.*—Eight cribs (32′ × 20′) have been placed on the prolongation of the north pier and the superstructure built upon them. The outer crib of the north pier (carried away in a storm last spring) has been replaced and ballasted with stone. To complete the proposed improvement of this harbor, the piers should be extended each 400 feet, at a cost of $52,000. The old slab pier should be removed to widen the entrance to the river, and the channel dredged to a depth of 12 feet. These two items would cost $30,000.

Amount on hand July 1, 1868	$13,315 11
Expended during the fiscal year	11,147 55
Balance on hand July 1, 1869	2,167 56

which will be entirely exhausted in payment for work done.

Amount required for the fiscal year ending June 30, 1871	$72,000 00

(See Appendix B 10.)

11. *St. Joseph's Harbor, Michigan.*—No work has been done at this place in the last fiscal year. The expenditures were for work already done. It has become evident from experience, that the present direction of the piers is erroneous. They should be placed in the actual direction

taken by the current of the river after it leaves the end of the present south pier, about north, 78° west, from the present west end of that pier. To permanently improve the harbor the south pier should be extended for a distance of 928 feet in this direction, and a north pier should be built parallel to it for a length of 940 feet. These two piers, it is estimated, would cost $116,666.

Amount on hand July 1, 1868	$7,500 00
Expended during the fiscal year	6,978 75
On hand July 1, 1869	521 25
Amount required for the fiscal year ending June 30, 1871.	$80,000 00

(See Appendix B 11.)

HARBORS ON LAKE HURON, IMPROVEMENT OF ST. MARY'S RIVER, AND OF THE ST. CLAIR FLATS.

Officers in charge, Brevet Major General T. J. Cram, colonel corps of engineers, retired; assistant, Captain H. C. Wharton, corps of engineers.

1. *Improvement of St. Mary's River, Michigan.*—During the past fiscal year the work for the improvement of the navigation of this river has been confined entirely to dredging in the middle channel of Lake George, in accordance with the original plan of making a channel 200 feet wide and 14 feet deep. It is expected that at the close of the present working season this work will be completed and the contract closed. The officer in charge reports that during the fiscal year there were excavated and removed 76,342 cubic yards of clay and sand.

Amount expended on the work during the fiscal year ending June 30, 1869	$38,053 10
Amount available July 1 for continuing the work	14,799 47

Special surveys have been made of other points in the St. Mary's River where improvements are required. The officer in charge estimates that to increase the channel to the necessary width and depth at these several localities will cost as follows:

East Neebish, west channel	$59,071 00
Channel at head of Rain's Island	56,380 00
Channel at foot of Sugar Island	19,570 00
Renewing boulders above canal	3,000 00
Renewing boulders below canal	3,000 00
Total	141,021 00

Amount required annually to keep the improvements in good condition, when completed	$10,000 00
Amount that could profitably be expended during the next fiscal year	60,000 00

(See Appendix C.)

2. *Improving mouth of Au Sable River, Michigan, Lake Huron.*—During the working season of 1868, thirty cribs were constructed and placed in position in line of piering. At the close of the season there were 240

linear feet of crib-work on the north side and 660 feet on the south. At the opening of the present season, damages caused by the gales and ice of the winter were repaired.

Amount available July 1, 1868	$45,502 38
Amount expended to June 30, 1869	31,794 46
Amount available July 1, 1869	13,707 92

The officer in charge reports that during the present working season he expected to extend the north pier by two cribs and the south by three cribs; to fill a breach made in the south pier with two cribs, and to complete the filling and superstructure on both lines of piers.

Amount required to complete the improvement according to original design	$20,000 00
Annual amount required to keep this harbor open after completion of work	3,000 00

(See Appendix C.)

3. *Improvement of mouth of Saginaw River, Michigan, Lake Huron.*—This work was completed on the 9th October, 1868, to the full extent contracted for. Dredging has been done throughout a length of 6,800 feet, giving a channel of 195 feet in width and 12 feet in depth "below the low stage during the calm weather of navigation."

Amount available July 1, 1868	$28,149 29
Amount allotted from general appropriation of 1868	9,000 00
	37,149 29

Amount expended during fiscal year, $36,043 54, leaving a small balance available for contingencies. The engineer in charge estimates that $1,500 will be required annually to keep the channel in good condition. (See Appendix C.)

4. *St. Clair Flats, Lake St. Clair.*—The total length of the proposed canal is about 8,200 feet; width between dikes, 300 feet; depth of water, 13 feet—below lowest stage known during navigation. Up to the close of the last fiscal year, June 30, 1869, there had been dredged about 4,320 linear feet of the canal bed to the full width and depth—the earth being placed in the banks—and about 7,028 linear feet of dike revetments and banks have been constructed.

Amount available from specific appropriation of 1866 and 1867, on July 1, 1868	$214,427 28
Allotment from appropriation of 1868	86,000 00
Allotment from appropriation of 1869	144,000 00
Total	444,427 28
Amount expended during fiscal year ending June 30, 1869	179,786 82
Available July 1, 1869	264,640 46

The officer in charge estimates that in addition to this sum there will be required to complete the improvement $15,000, and an annual appropriation for repairs of $1,500. (See Appendix C.)

HARBORS ON LAKE ERIE, WEST OF DUNKIRK.

Officer in charge, Major Walter McFarland, corps of engineers.

1. *Monroe Harbor, Michigan.*—Nothing has been done here; though since the close of the year the work of dredging the bar and protecting the north pier has been let, to be completed probably by the beginning of winter.

Balance June 30, 1868	$10,590 21
Expended during the fiscal year	178 73
On hand July 1, 1869	10,411 48

No further appropriation is asked. (See Appendix D.)

2. *Harbor of Toledo, Maumee Bay, Ohio.*—Nineteen thousand one hundred cubic yards of sand were removed from the channel. The project of a straight ship canal through Maumee Bay, which was submitted by General Cram, was referred by me to a board of engineers, which recommended in its stead the improvement of the western channel by dredging. The recommendation of the board was approved by me. and the reports were submitted to the Secretary of War, and by him transmitted to Congress. Since the termination of the year an allotment ot $30,000 has been made for dredging the western channel, which will be expended by the close of navigation. To put this channel in condition suitable to the magnitude of the commerce of Toledo and its rapid growth, there will be required, in addition, $120,000.

Balance June 30, 1868	$13,015 01
Expended during the fiscal year	10,715 51
Balance July 1, 1869	2,299 50

(See Appendices D 1 and D 2.)

3. *Sandusky River, Ohio.*—The operations of the year have consisted in cutting channels sixty feet wide and eight feet deep through the first shoal place below Whitacie Bar, through the bar off Squaw Island, and the bar at the mouth of the river—removing altogether 27,353 cubic yards of material.

Balance June 30, 1868	$8,340 21
Expended during the fiscal year	7,990 77
On hand July 1, 1869	349 44

There could be profitably expended in improving these channels in the coming year, $20,000. (See Appendix D 3.)

4. *Sandusky City Harbor, Ohio.*—The channel over the outer bar has been widened to two hundred and forty feet during the year, and deepened to twelve feet, excepting in two places where the depth is eleven feet six inches. The balance of the appropriation is to be applied to the improvement of the channel over the inner bar. To make this channel two hundred and fifty feet wide an additional appropriation of ten thousand dollars is needed.

Balance June 30, 1868	$24,353 76
Expended during the fiscal year	13,988 70
On hand July 1, 1869	10,365 06

All of which will be expended during the present season in deepening the channel over the inner bar. Required for the next fiscal year, $10,000. (See Appendix D 4.)

5. *Huron Harbor, Ohio.*—Nothing has been done in the improvement of this harbor during the past fiscal year. Since its close, however, estimates of the cost of necessary repairs in both piers have been made, advertised, and the work let, to be completed this fall.

Balance on hand June 30, 1868	$13,774 31
Expended during the fiscal year	200 95
On hand July 1, 1869	13,573 36
Probable cost of repairs during the present working season	2,500 00
Leaving available	11,073 36

To be applied to further repairs as the necessity for them arises, which will not probably amount to more than $1,500 per year. No further appropriation is asked. (See Appendix D 5.)

6. *Vermillion Harbor, Ohio.*—Nothing has been done since the close of the last fiscal year, the piers being in very good condition, and giving no indications of needing further repairs very soon. The appropriations and allotments for this work are exhausted. Probable annual cost of keeping the piers in repair, $1,000. (See Appendix D 6.)

7. *Black River Harbor, Ohio.*—Nothing has been done here during the past year; but the work of repairing the west pier is now in progress. The channel in July of 1869 was twelve feet deep, or about ten and a half feet deep at low water—an increase of two feet over the depth reported in November last.

Available June 30, 1868	$10,000 00
Expended during the fiscal year	24 58
On hand July 1, 1869	9,975 42

No further appropriation is required. (See Appendix D 7.)

8. *Cleveland Harbor, Ohio.*—The west pier has been completed, and the east pier extended so far that its completion may be expected in September.

Balance on hand July 1, 1868	$30,858 99
Allotted from appropriation of 1868	17,000 00
Allotted from appropriation of 1869	12,000 00
	59,858 99
Expended during the year	39,427 05
On hand July 1, 1869	20,431 94

All of which will be expended this year in completing the pier extension. Required, as by previous reports, to give fourteen feet draught, $39,000, which can be profitably expended during the fiscal year. (See Appendix D 8.)

9. *Grand River Harbor, Ohio.*—The east pier extension has been completed and the effect has been to give an average increase of depth of two feet in the channel. Further improvement is deferred until it

can be decided whether an extension of the west pier will best accomplish the end desired.

Balance available July 1, 1868	$45,582 40
Expended during the fiscal year	10,777 37
Balance on hand July 1, 1869	34,805 03

No further appropriation is required. (See Appendix D 9.)

10. *Ashtabula Harbor, Ohio.*—The extension of both the east and west piers has been completed, both running out now to the twelve-foot curve, and they are of equal length and parallel. The contract for dredging the harbor out to twelve-feet depth is let at a reasonable rate, and will probably be completed this year. No further appropriation is needed.

Amount on hand June 30, 1868	$48,310 16
Expended during the fiscal year	28,412 94
Balance on hand July 1, 1869	19,897 22

Which is sufficient to complete the dredging, and which will probably be expended by December. (See Appendix D 10.)

11. *Conneaut Harbor, Ohio.*—The breach made by Conneaut Creek into the lake and behind the east pier has been repaired, and the place secured against a similar accident. The cribs of the west pier extension were sunk in place in June, since which time the entire extension has been completed.

Received and expended during the year	$14,213 74
Allotted from appropriation of April 10, 1869	9,000 00

Which has been expended in completing the pier work.

Still to be appropriated, in order to complete the harbor, $6,000. (See Appendix D 11.)

12. *Erie Harbor, Pennsylvania.*—The work at this harbor during the past year has consisted of the repair of three-quarters of the damaged north pier, and the dredging of the channels over the inner and the outer bars. The former work has stood the storms of fall and winter without any perceptible settlement, proving the propriety of the system of repair adopted. The channel over the inner bar has been deepened to thirteen feet below low water for a width of one hundred feet, and a lump has been removed from the outer bar. There have been expended $21,173 76 in these operations.

Balance on hand June 30	$33,500 00
Since allotted	22,500 00
To be expended this season	56,000 00
Leaving, of the amount called for in the last annual report. Still to be supplied by appropriation, to which must be added	$15,150 00
the cost of widening the channel	30,750 00
Total required	45,900 00

(See Appendix D 12.)

HARBORS ON LAKE ERIE, EAST OF ERIE, PENNSYLVANIA.

Officer in charge, Brevet Lieutenant Colonel Franklin Harwood, captain corps of engineers.

1. *Dunkirk Harbor, New York.*—The west pier while in progress of construction, and nearly completed, was breached by the gale of the night of the 7th October, 1868. Owing to the lateness of the season the work was closed and secured for the winter. In the spring of 1869 the work of repair, reinforcement, and completion of this work was commenced, and at the close of the fiscal year was progressing. The construction of the new breakwater was commenced in the spring of 1869, and at the close of the fiscal year was in a forward state. The removal of the old outer breakwater had not yet been undertaken, but it was to be removed during the working season. It was expected that the west pier and a section of the breakwater (about nine hundred feet) would be completed by the close of the working season of 1869, exhausting the present appropriation, excepting a small balance retained for contingencies of repair. The recommendations of the last annual report are renewed.

Amount on hand July 1, 1868	$91,666 55
Received during the fiscal year	60,166 55
Expended during the fiscal year	48,985 31
On hand July 1, 1869	42,681 24
Amount required, and which can be profitably expended during the fiscal year ending June 30, 1871	100,000 00

(See Appendices E, E 1, E 2, and E 3.)

2. *Buffalo Harbor, New York.*—The interior works of repair are nearly completed. The south pier has been extended three hundred and eighteen feet; but the dredging is deferred until the completion of the repairs of the piers. One hundred and fifty feet of the breakwater has been built to the low water level. It is expected that the interior harbor work will be completed during the present working season, and that there will be built by the close of the year 1870 from one thousand to one thousand two hundred feet of the breakwater, of which about eight hundred feet will be constructed under existing contracts, and the remainder from $90,000 allotted from the general appropriation of 1869.

Amount on hand July 1, 1868	$193,124 82
Received during the fiscal year	119,124 82
Expended during the fiscal year	105,865 12
On hand July 1, 1869, including amount allotted from appropriation of April 10, 1869, ($89,100)	176,359 70
Amount required, and which can be profitably expended, for the fiscal year ending June 30, 1871	220,000 00

(See Appendices E and E 4.)

HARBORS ON LAKE ONTARIO.

Officer in charge Brevet Colonel N. Bowen, major corps of engineers, assisted by Captain W. A. Jones and First Lieutenant B. D. Greene, corps of engineers. (These harbors were in charge of Brevet Colonel Blunt, corps of engineers, until January, 1869, and of Brevet Brigadier General McAlester, corps of engineers, until his death, April 23, 1869.)

1. *Olcott Harbor, (Eighteen Mile Creek,) New York.*—Since last annual report two hundred and seventy-five running feet of the west pier have been completed, and seventy running feet of cribs filled with stone, without the superstructure. Two cribs of the east pier were sunk before the winter set in. Dredging has been done in the channel and on the line of the piers. The contracts for material and labor have been annulled, and in future the work will be done by days' labor. It is proposed during the coming year to continue the dredging in the channel and on the line of the piers, and to carry out the two piers as far as the appropriation will justify.

Amount available for the work July 1, 1868	$50,671 67
Amount available July 1, 1869	21,312 46
Required for the fiscal year ending June 30, 1871	50,000 00

(See Appendix F.)

2. *Oak Orchard Harbor, New York.*—Owing to the failure of the contractor for labor to comply with his contract, it was canceled and the work re-let. The loss of time consequent on this was very serious, and but little work has been done. The gap in the west pier has been finished except decking over. The old superstructure of the east pier has been removed, and three hundred running feet of cribs have been sunk and filled with stone. Dredging has been done in the channel and on the line of the piers. It is proposed during the coming year to expend the whole of the balance remaining on hand in continuing the work on the east and west piers and on dredging in the channel.

Amount available for this work July 1, 1868	$74,793 00
Amount available for this work July 1, 1869	45,350 43
Amount required to complete the work proposed to be done during the fiscal year ending June 30, 1871	50,000 00

(See Appendix F.)

3. *Harbor of Charlotte, New York, (mouth of the Genesee River.)*—This work progressed satisfactorily during the year until the appropriation became exhausted. Two thousand one hundred and ninety-eight running feet of cribs have been sunk and filled with stone upon the east pier, and were decked over for the security of the stone filling. There only remains to complete this pier forty eight feet of crib-work, two hundred and sixteen feet of superstructure, and the pier-head. An appropriation of $30,000 is urgently needed for this purpose, and $15,000 to secure the end of the west pier at its junction with the bank of the river. The officer in charge recommends the sale of portions of the west pier, at cost, to private parties, for wharfage, the proceeds of such sale to be used for repairing the pier proper.

Amount available for the work July 2, 1868	$19,995 94
Amount available for the work July 1, 1869	71 80
Amount required for the fiscal year ending June 30, 1871	45,000 00

(See Appendix F.)

4. *Big Sodus Harbor, New York.*—The pier has been completed with the exception of the light-house head, 776 feet having been built during the fiscal year. There is material enough remaining on hand to add 90 feet to the length of the pier, before putting on the pier-head. This will be done during the coming season. The dredged channel has been

increased to width of 200 feet. To complete the closing of the space between the entrance and the east shore will require an appropriation of $30,000; to dredge the channel to the full width between the piers, $35,000; for necessary repairs, $10,000. This is the finest natural harbor on the lake, but its commerce is insignificant.

Amount available for this work July 1, 1868	$58,645 46
Amount available for this work July 1, 1869	8,056 53
Amount required for the fiscal year ending June 30, 1871	35,000 00

(See Appendix F.)

5. *Little Sodus Harbor, New York.*—The superstructure was completed upon the three hundred feet of pier which remained unfinished last season. The width of the dredged channel has been increased from eighty to two hundred feet. It was found in the spring that the pier had sunk several feet in some places, probably owing to dredging too near the face of the pier, and to the shifting sand of which the bottom is composed. Proposals have been received for the extension of the pier 150 feet, which will be completed this season, and will exhaust the present appropriation. To complete this improvement as originally proposed will require an additional sum of $35,000, and to restore the sunken parts of the present pier and to rebuild the breakwater $25,000 will be required.

Amount available for this harbor July 1, 1868	$27,860 51
Amount available for this harbor July 1, 1869	4,017 39
Amount required for the year ending June 30, 1871, to make the necessary repairs, and to dredge so much as may be required to clear the channel	25,000 00

(See Appendix F.)

6. *Oswego Harbor, New York.*—The work of the fiscal year has been confined to repairs of the United States pier and dredging the space inclosed by it.

It was proposed to prolong the pier 400 feet northerly during the fiscal year, but the work being unavoidably delayed, it will not be completed until the close of the present working season.

For the next fiscal year there will be required to complete the repairs undertaken this season and other repairs that may be necessary, $35,000. This amount will level up and refill the whole of the old pier, repair breaches in the old stone parapet, and put the work in good order.

Amount available for this work July 1, 1868	$49,823 90
Allotted from appropriation of 1868	20,000 00
Allotted from appropriation of 1869	22,500 00
Expended during the fiscal year	20,997 69
Amount available July 1, 1869	70,326 23
Amount required for the fiscal year ending June 30, 1871	35,000 00

(See Appendix F.)

7. *Ogdensburg Harbor, New York.*—A contract was entered into last autumn for dredging in the Oswegatchie River, below the bridge, and upon the outer bar north of the light-house. At the end of the fiscal year the channel through the outer bar had been completed. During the remainder of the present working season, dredging in the river below the bridge will be continued until the available funds are exhausted. A recent survey shows a clear channel at least 12 feet deep below low

water, and averaging 300 feet in width. No difficulty is experienced in entering the river.

Amount available for this work July 1, 1868	$37,118 58
Amount available for this work July 1, 1869	19,272 49

No additional amount is asked for this harbor until the effect of the dredging recently carried on is fully developed. (See Appendix F.)

HARBORS ON LAKE CHAMPLAIN.

Officer in charge, Brevet Lieutenant Colonel J. W. Barlow, captain corps of engineers.

1. *Plattsburg Harbor, New York.*—The repairs on the breakwater having been completed, the available balance of the specific appropriation for the improvement of this harbor ($6,212 38) has been applied to increasing the depth of water on the shoal between the breakwater and the wharves. By dredging, a depth of seven feet has been obtained on this shoal. The recommendation of last year is renewed, that the depth of water in this harbor be increased to nine feet. The demands of the increasing commerce of this port would seem to require a further extension of the breakwater. The officer in charge recommends an extension of three hundred feet to the northward. He also recommends that the foot of the slope along the government reservation be revetted.

The estimated cost of these improvements is	$50,000 00
Amount of funds available July 1, 1868	$6,212 38
Expended during year ending June 30, 1869	5,631 53
Balance remaining July 1, 1869	580 85
Amount that could be profitably expended on this harbor next season	$25,000 00

(See Appendix G.)

2. *Burlington Harbor, Vermont.*—The work now in hand for the improvement of this harbor consists of an extension of the breakwater in accordance with the plan adopted and referred to in previous reports. During the working season of 1868, six cribs were placed in position and filled with stone, giving five hundred lineal feet additional length of breakwater. During the present working season the work has been resumed, and it is expected that with the amount of money available for this improvement, one hundred and sixty feet of crib-work will be completed, making a total extension of six hundred and sixty feet, leaving about eight hundred and forty feet of breakwater to be built to complete this work in accordance with the plan adopted.

Estimated cost of extension, (1,500′)	$333,442 00
Estimated cost of completion, (840′)	150,000 00
Amount available July 1, 1868	$90,927 10
Amount expended during the year	48,912 16
Balance available July 1, 1869	42,014 94
Amount required for next fiscal year	$75,000 00

(See Appendix G 1.)

SURVEYS AND IMPROVEMENTS OF THE UPPER MISSISSIPPI, MINNESOTA, AND WISCONSIN RIVERS, AND CONSTRUCTION OF THE ROCK ISLAND BRIDGE.

Officer in charge, Brevet Major General G. K. Warren, Major corps of Engineers, assisted by Brevet Major A. Stickney, captain corps of engineers.

1. *Surveys and maps of the Upper Mississippi River.*—During the last fiscal year surveys and examinations were made at the sites of bridges between St. Louis and St. Paul, also of the harbors of Dubuque and Alton, with the view of preparing projects for preventing the injury caused by sand bars. It is very desirable that the survey of the river should be extended down to La Crosse, in order to embrace, some very shoal places found between that point and Winona. General Warren recommends that a survey and examination be made above the Falls of St. Anthony with the view of ascertaining the practicability of forming large reservoirs on the headwaters of the Mississippi to aid in keeping up the navigation at low stages. To make these surveys and examinations and complete the maps, together with the maps of thesurveys previously made, will require an appropriation of $25,000. (See Appendix H and H 3.)

2. *Dredge and snag-boats on the Upper Mississippi River.*—The two boats, Montana and Caffrey, were put in good order in the beginning of the season of 1868. One of the boats was soon called into requisition by the low water, and the work of that season fully demonstrated the success of the method of deepening the water on the bars by scraping. During that season one of the boats was employed one hundred and twelve days, and the other sixty-seven days. During the season of 1869, the low water again called for work on the part of the Caffrey early in July, and she prevented any suspension of navigation by the largest boats. Owing to the rise in August, the Caffrey was laid up on the 8th, and the Montana has been employed in removing snags, stumps, and overhanging trees. The successful working of these boats, reported in the last annual report, is confirmed by the experience since acquired. In the upper part of the river there are several small channels which draw off the water from the main channel. It is desirable that these should be closed. For the improvement of the Upper Mississippi River, operating scraper and snag-boats, (including repairs,) and for dams to close channels injurious to navigation, there will be required for the next fiscal year $51,000. (See Appendix H 1.)

3. *Wisconsin River.*—The officer in charge of this improvement expects to be able to present a full special report on the subject during the coming winter. A careful reconnoissance has been made to fill in details which were not covered by the survey of 1867. The maps are now nearly completed. A small steamer has been purchased for snagging operations and has been put to work at Portage with the design of clearing the channel way of snags and leaning trees—working down stream. A very great impediment to navigation now consists in the railroad and wagon-road bridges. The draws are too narrow, and some completely choked with sand. Dams are required to free these draws from sand bars.

For the next fiscal year, for continuing the operations of the snag and dredge boats and for building dams, there will be required $115,000. (See Appendix H.)

4. *Improving Minnesota River.*—The appropriation made in 1867 for removing the snags and bowlders from the river has been exhausted. It is desirable that the improvement should be continued, and for this purpose there will be required for the next fiscal year $15,000. (See Appendix H.)

5. *Du Luth and Bois Fort Reservation road.*—In the act making appropriation for the support of the army for the year ending June 30, 1870, ten thousand dollars were appropriated for the purpose of cutting out a road from Du Luth to the Bois Fort Indian reservation, in Minnesota. Although this money was not available until July 1, 1869, steps were taken to ascertain the best way to carry on the work. After an examination made by Major Stickney, it was determined that the most judicious outlay of the money appropriated would be to bridge the river, improve the swamp crossings on the line of Mr. Stuntz's road, to a point near the second crossing of Vermillion River, and thence cut out a road to Pelican Lake. A small party has been at work during the present working season, but have been much delayed by rains and flooded streams. (See Appendix H.)

6. *Rock Island bridge.*—By direction of the Secretary of War, the construction of the bridge over the Mississippi River at Rock Island was placed under the control of the Engineer Department, and General Warren, on the 10th July, was assigned to the immediate charge of the work. He was directed to submit preliminary estimates of the cost of the bridge, and in the mean time to suspend the execution of the contracts for the construction of the piers. These estimates providing for a double-track railroad and wagon road in accordance with the requirements of the act of Congress making appropriation for the bridge, exceeded the limits of expenditure prescribed in the act, and General Warren was directed to go on with the construction of the piers, which will admit of a double-track or single-track superstructure, and to prepare estimates carefully for superstructures of single-track railroad and wagon road, and also of double-track railroad and wagon road, with a view to submitting the subject to Congress for decision. In his annual report General Warren presents the question of the cost of this bridge in a clear light.

Amount appropriated	$700,000 00
Amount required for next fiscal year	300,000 00

(See Appendix H.)

IMPROVEMENT OF THE DES MOINES AND ROCK ISLAND RAPIDS OF THE MISSISSIPPI RIVER, AND SURVEY AND IMPROVEMENT OF THE ILLINOIS RIVER.

Officer in charge, Brevet Major General J. H. Wilson, lieutenant colonel United States Army, assisted by Captain and Brevet Major Charles J. Allen, Captain L. Cooper Overman, corps of engineers, and Lieutenant E. F. Hoffman, United States Army.

1. *Improvement of the Des Moines Rapids of the Mississippi River.*—This improvement consists in the construction of a canal around the rapids, and the work is naturally divided as follows: Excavation of prism and construction of embankment wall, building of locks, and the excavation of the Montrose Channel. The completion of any one of these separate pieces of work is of no advantage to commerce and navigation until all are finished. Work has been begun on the lower lock, upon the prism and embankment wall of the canal, and contracts have been made for furnishing cement for the lower lock, and stone for

all the locks. No work has been done upon the channel improvement at Montrose, nor upon the guard and middle locks, all the money now available being pledged for other work.

During the past fiscal year the work has been carried on with varied success by contract, and for a time by "day's labor." Owing to the failure of the original contractors (Henegan & Son) new proposals were invited for the excavation of the prism and the construction of the embankment wall of the canal, and on December 12, 1868, a contract was made with Mr. J. J. Dull, the successful bidder.

The contractor for stone, Mr. Tobie, having failed, a contract was entered into with Charles G. Case & Co. to furnish the necessary stone.

Amount appropriated June 23, 1866	$200,000 00
Amount appropriated March 2, 1867	500,000 00
Amount allotted July 30, 1868	300,000 00
Amount allotted May 11, 1869	178,200 00
Total	1,178,200 00
Amount expended to June 30, 1869, including retained percentage	433,121 21
Available July 1, 1869	745,078 79

Amount required for the completion of the work according to revised estimate of General Wilson	$1,410,000 00
Amount required for next fiscal year	1,000,000 00

Owing to the extraordinary rain-fall and continued high water, the progress made in carrying work forward has not been satisfactory during last season; still, much work has been done, and it is believed that with a favorable season next year, and with the necessary appropriation of money, the greater part of the work can be completed by the winter of 1870–'71. (See Appendix I.)

2. *Improvement of the Rock Island Rapids of the Mississippi River.*—This work has been carried on during the year by Messrs. Case & Co., under their contract of June 28, 1867, and extension of December 2, 1868. From Duck Creek chain 9,900 cubic yards of rock have been excavated and removed, substantially completing the improvement of the chain. At Moline chain the coffer dam was completed July 30, 1868, and at the close of this fiscal year 16,900 cubic yards of rock were removed, leaving about 2,000 yards for completion. At Sycamore chain the coffer dam, inclosing about forty-five acres, was completed on November 14. About 15,800 cubic yards of rock have been removed, and at the close of the fiscal year there were about 1,400 yards to be excavated to complete this chain. During the present working season the contractors were greatly delayed by unfavorable weather and high stage of water in the river. Work was, however, commenced on Campbell's chain, and the coffer work, with a development of 3,660 linear feet, was completed; but at the end of the month of August it was impracticable to clear the dam of water.

Amount appropriated June 23, 1866	$100,000 00
Amount appropriated March 2, 1867	200,000 00
Amount allotted August, 1868	156,000 00
Amount allotted May 11, 1869	133,650 00
Total	589,650 00

Amount expended to June 30, 1869, including reserved percentage	$453,193 50
Amount available July 1, 1869	136,457 50
Amount required for next fiscal year	300,000 00

(See Appendix I.)

3. *Survey and improvement of the Illinois River.*—Field operations on the Illinois River were confined to examinations of sites for locks and dams in connection with the improvement proposed in 1867. The General Assembly of Illinois has directed the construction of one lock and dam on this river, to form the first link in the improvement, substantially conforming to the general plan previously recommended. This lock and dam is located at Henry, Illinois, and it is designed that the dam should be of such a height as will set the water back to a depth sufficient to flood all the bars at low water without dredging between the dam and the town of Utica. To lessen the height of the second dam contemplated near the mouth of Copperas Creek, it is proposed to dredge the bars intervening to a depth sufficient to furnish seven feet of water in the pool. The dam at Henry will extend the Illinois and Michigan Canal thirty-one miles, and with the dredging proposed will give Peoria, the most important city on the lower river, good water communication with Chicago. This dredging, it is believed, can be accomplished with the sum of $85,000 allotted from the general appropriation for improvement of rivers and harbors, approved April 10, 1869. Amount required for the next fiscal year for the construction of one dam and lock, $300,000. (See Appendix I.)

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER.

Officers in charge, Brevet Brigadier General M. D. McAlester, major corps of engineers, to November 21, 1868; Brevet Colonel F. E. Prime, major corps of engineers, from November 21, 1868, to April 16, 1869; Lieutenant D. W. Payne, corps of engineers, to June 7, 1869, and since that date Brevet Major C. W. Howell, captain corps of engineers, having under his orders First Lieutenants M. B. Adams and D. W. Payne, corps of engineers.

The early part of the fiscal year until the 3d of September was consumed in completing the construction, equipment, and delivery at New Orleans of a dredge-boat specially designed for this work by Brevet Brigadier General M. D. McAlester, then in charge. On the 3d of September this dredge-boat (the Essayons) commenced work on the bar at the mouth of Pass à Loutre, and from that time until the 18th of June, 1869, was employed sixty-nine and a half working days in dredging a channel through the bar. As the result of this labor, the depth of water on the bar was increased from eleven feet six inches to seventeen feet eight inches, and a clear, direct channel, 175 feet wide at the narrowest part and seventeen feet eight inches in depth, made available for commerce on the 18th of June. The work was not as continuous as could have been desired, owing to accidents to the machinery and consequent delays which could not be foreseen and guarded against; nor was it at any time sufficiently uninterrupted to obtain the maximum depth (twenty feet) for which the dredge is calculated, and which experience has shown it can obtain and preserve by continuous work. The dredge-boat will be laid up at New Orleans during the sickly season and thoroughly repaired. Such alterations and additions to her machinery as have been shown to be desirable and essential to her future success will also be made. The plan of improvement adopted (by the use of the double-ender dredge-boats, fitted with an excavating screw and rake

or scraper) has proved to be the best heretofore attempted, and if fully carried out will produce the result desired, viz: the permanent opening of the Mississippi River to vessels of great draught. To fully carry out the plan it will be necessary to build the second of the two dredge-boats authorized by the joint resolution of Congress, approved March 29, 1867, and employ her on the work in conjunction with the boat already so employed.

During the fiscal year the barge Cavallo was purchased as a tender to the Essayons, and an end dock built for the repair of the dredging screw. Both are in good condition.

It is desirable that measures be taken for guarding the channel excavated from damage, which may be caused by vessels grounding on its sides—an event that may occur from carelessness or from crowding the narrow channel.

The allotment for the current fiscal year, added to the unexpended balance on hand, amounts to $57,887 51. During the next fiscal year $365,000 can be profitably expended upon the work, and is absolutely essential to its complete success. Of this amount $275,000 is estimated for the construction and delivery of the second of the two dredge-boats authorized, $70,000 for working expenses, repairs, &c., of the dredge-boat Essayons, and $20,000 for working expenses of the second dredge-boat for three months. (See Appendix J.)

SURVEY OF THE MOUTH OF THE ST. JOHN'S RIVER, FLORIDA.

To comply with a request from the Committee on Commerce of the Senate, asking for "estimates of the expense of deepening the channel of the St. John's River, Florida, so that it will answer the demands of commerce," Brevet Major General Q. A. Gillmore, corps of engineers, was instructed to cause a survey and examination of that locality to be made, with the view of obtaining the latest requisite information to be laid before the committee. General Gillmore proposes, in his report of this survey, in preference to other more expensive projects which have been heretofore suggested for the improvement of this entrance, to try the simple plan of deepening the channel by repeated dredgings or rakings during the strongest stage of the ebb current, as promising at least a fair measure of success at a comparatively small cost. He thinks that a constant minimum depth of at least ten feet at mean low water, with a width sufficient for the purposes of navigation, may be secured on the bar at a cost not exceeding $10,000 per year, and that the merits of the method proposed may be tested at an expenditure of not exceeding $5,000. The project seems to meet the present wants of commerce and navigation, and it would be advisable to make the small appropriation recommended. This method, however, of improving the depth of water on the bar should be considered as purely experimental, and if it be successful it will only afford temporary relief; for experience has shown that if the channel through the bar is not fixed but is ever changing, depending upon the force and direction of the storms, even apart from the consideration of the effects of storms, the deepening must be continuous to maintain the depth when once secured. (See Appendix K.)

IMPROVEMENT OF THE NAVIGATION OF THE FALLS OF THE OHIO, AND ENLARGEMENT OF THE LOUISVILLE AND PORTLAND CANAL—IMPROVEMENT OF THE TENNESSEE RIVER.

Officer in charge, Brevet Major General G. Weitzel, major corps of engineers.

1. *Dams at the Falls of the Ohio.*—An allotment of $85,000 was made

from the appropriation of July 25, 1868, for the construction of a crib dam across the crest of the rocks in front of Louisville to raise the low-water mark about three feet. In consequence of high water the necessary surveys and soundings, to determine the best position for the two dams at the head and foot of the falls, could not be finished in time to commence work before the winter set in. But at the date of this report contracts had been awarded for material and labor for the upper dam, nearly all the material has been received, and the work upon that dam begun. (See Appendix L.)

2. *Enlargement of the Louisville and Portland Canal.*—An allotment of $180,000 from the appropriation of April 10, 1869, for the improvement of harbors and rivers, has been made to be applied to the completion of the Louisville and Portland Canal. The United States are virtually the owners of this canal, and the work of enlargement being still unfinished, and the wants of commerce imperatively demanding the completion of this enterprise, it became a question whether, in view of the terms of the resolution of Congress of 1860, authorizing the president and directors of the company to enlarge the canal, using therefor the revenues and credits of the company, any portion of this appropriation for rivers and harbors could be applied to the work of enlargement, or in any manner towards the improvement of the canal until the five individual shareholders transfer to the United States all the right, &c., they now hold in trust.

Although the subject has been frequently brought to the attention of Congress, yet no act or resolution has ever been passed specifically accepting the conditions of the act of the legislature of Kentucky of 1842, (for the sale to the United States of the shares belonging to individuals,) and authorizing or directing any officer of the United States to receive the bonds held by the trustees and assume the control of the canal. These individual shareholders, now composing the Louisville and Portland Canal Company, deem it their duty not to surrender their trust unless the United States assume the indebtedness of the company, which, up to this time, it has not done, and virtually refuses to do. While this anomalous condition of things continues—five individuals holding United States property in trust by authority of the legislature of a State, and controlling public property which has cost millions, and still unable to complete the canal improvement without increasing its debt—the heavy tax upon the commerce of our most important rivers is continued, and the navigation of the Ohio is most seriously obstructed.

The only practicable mode of reaching the end in view appears to be annual appropriations from Congress until the work is finished; the tolls of the canal being used for the payment of its working expenses, and the absorption of its debt, which they are adequate to.

The subject was laid before the Secretary of War with the opinion that, after careful examination and consideration, an allotment of some portion of the appropriation could be made for the enlargement of the canal, which recommendation met with his approval, and the officer in charge was directed to apply the whole of this allotment and whatever might be left from the first allotment, after the upper dam across the river was built, to this object.

It is proposed with this allotment first to enlarge and improve the entrance to the head of the canal as far as the upper guard gates, and then to apply whatever balance there may be to opening the new locks into the main trunk of the canal. The material for the work upon the dam at the head of the canal has been purchased and the work begun, and bids have been invited for the excavation required inside of this dam.

Amount expended during the fiscal year for the dam at the falls	$26,054 47
Balance on hand and in treasury, July 1, 1869	238,945 53
Estimated cost of Louisville and Portland Canal extension	933,500 00
For two dams and one lock across the falls of the river at Louisville	310,000 00
	1,243,500 00
Allotted from appropriations of 1868 and 1869	265,000 00
Total required	978,500 00
Required for the fiscal year ending June 30, 1871, and which can be profitably expended	$450,000 00

(See Appendices L and L 1.)

3. *Improvement of the Tennessee River.*—During the present season the work upon this improvement has been at the three points between Chattanooga and Decatur, where the chief impediments to steamboat navigation in that part of the river are found—Tumbling Shoals, the Suck, and the Pot. A contract has been entered into and the work at the Suck has been prosecuted as vigorously as the stage of water during the season permitted; and it is hoped that all the work required at these points will be completed this year.

The officer in charge renews his recommendation for an appropriation of $500,000 towards the enlargement of the old canal between Lamb's and Campbell's ferries as being of the first importance in connection with the removal of the obstacles to the navigation of the river, and asks for the sum of $10,000 for additional surveys for the purpose of forming estimates of cost of canals around the Elk River and Little Muscle Shoals.

Amount allotted to Tennessee River improvement:

From appropriation of July, 1868	$85,000 00
From appropriation of April, 1869	40,500 00
Total	125,500 00
Expended during the fiscal year	15,209 69
Balance on hand July 1, 1869	110,290 31

(See Appendices L 2 and L 3.)

IMPROVEMENT OF WESTERN RIVERS, EXCEPTING THE OHIO.

Officer in charge, Colonel J. N. Macomb, corps of engineers, assisted by Brevet Major C. R. Suter, captain corps of engineers.

1. *Construction of snag-boats and machinery.*—At the commencement of the fiscal year, July 1, 1868, the three double-hulled snag-boats, viz., the J. J. Abert, the S. H. Long, and the R. E. De Russy, had been but a short time in service, but had given promise of the good work that this year's record shows for them. In the course of the year, one snag-boat, the S. Thayer, and one dredging-boat, the Octavia, have been added to the list. The snag-boat is of light draught, and was built for use in the

Arkansas River. The dredging-boat was purchased, having been found upon trial to be well adapted to this service.

2. *Examinations and surveys.*—During the summer of 1868 a partial survey of the lower part of the Missouri River was made. During the past winter a careful reconnaissance was made and mapped of the Mississippi River continuously, with but few breaks, from Alton, Illinois, to Grand Gulf, Mississippi. During the present season a similar reconnaissance has been pushed up the Missouri, which has been mapped from the mouth to Yankton, Dakota. These maps are for the use and guidance of the operations for the improvement of the navigation of these rivers.

A surveying party, in charge of Mr. S. T. Abert, civil engineer, has been organized for the survey of the Arkansas River. The survey was begun at Fort Gibson and continued to Little Rock, a distance of three hundred miles. The final report will show the results of this survey under the heads of the physics and hydraulics of the river. (For preliminary report see Appendix M.)

3. *Improvement of the Mississippi, Missouri, and Arkansas Rivers.*—This has consisted in removing and destroying snags, cutting trees to prevent the formation of snags, and in dredging bars in these rivers, and has been pushed forward vigorously during the last fiscal year by laying out the field into districts and keeping the boats at work as nearly together as possible, so as to admit of more easy supervision. In this way a large amount of work was done on the Mississippi during the winter and on the Missouri during the summer. The work on the Arkansas, requiring a boat of very light draught, was begun as soon as the boat was ready for service, and has continued with good progress since the month oi May, 1869. The most sanguine expectations as to the success of the boats in this service for the past year have been realized, and, while they have all done remarkably well, they have demonstrated the necessity of having more boats, and particularly some of lighter draught of water.

There is a practical difficulty in combining the great strength which it is desirable that a snag-boat should possess with the lightness of draught requisite for working at the lowest stage of water, when the most dangerous snags become visible. Since these boats began to operate changes have been made in points of minor detail which have simplified and expedited the process of destroying snags and at the same time shown the feasibility of making a lighter draught boat that will do the work effectively.

An account in detail of the localities at which the snag-boats were employed will be found in Appendix M.

The following is a recapitulation of the work done during the year ending June 30, 1869:

Name of snag boats.	Number of snags pulled and destroyed.	Weight of snags in tons of 2,000 pounds.	Number of trees cut down.	Roots cut off trees under the bank.	Drift piles removed.
J. J. Abert	952	12,865.14	4,648	145	7
S. H. Long	767	13,006.05	3,789	434	25
R. E. De Russy	928	9,161.04	4,727	None.	4
S. Thayer	50	726.2	None.	None.	None.
Grand total	2,697	35,758.9	13,165	579	36

Amount required for the next fiscal year:

Repairs of snag and dredge boats, and working the same during the remainder of the present fiscal year	$166,000 00
For current expenses of the same during the fiscal year ending June 30, 1871	255,000 00
Total	421,000 00
For building three additional boats, and for operating the same during the fiscal year ending June 30, 1871	329,000 00
Grand total	750,000 00

(See Appendix M.)

KANSAS CITY BRIDGE.

Upon the representation of owners, captains, and pilots of boats navigating the Missouri River, and others interested, that the bridge about to be built across the Missouri at Kansas City greatly endangered navigation at all times, but especially during high water, and was not passable with any degree of safety, with the view of obtaining all the facts of the case, Colonel Macomb, corps of engineers, in charge of western river improvements, was directed to cause the necessary examination to be made. The report of Brevet Major C. R. Suter, captain corps of engineers, upon this subject, will be found in Appendix M 1.

RIVER CHANNELERS OR EXCAVATORS.

A plan proposed by Brevet Major C. W. Howell, corps of engineers, for channeling through the sand-bars which obstruct the navigation of the western rivers, with a description of the machine devised for the purpose, will be found in Appendix M 2.

WASTE LANDS—MISSISSIPI RIVER.

By a resolution of the House of Representatives of February 5, 1869, the Secretary of War was requested to furnish the House with a copy of a memoir addressed to him by Brevet Brigadier General B. S. Roberts, United States Army, upon the subject of draining the surplus waters of the lakes into the Upper Mississippi, Illinois, and Ohio rivers, and of reclaiming the waste lands of the Lower Mississippi.

This resolution was referred to this office by the Secretary of War for a report upon the merits of the plan proposed by General Roberts.

Copies of my letter to him, of the memoir in question, and of a communication made by me in February, 1866, to General Delafield, then Chief of Engineers, upon the feasibility and expediency of carrying into effect the views presented in the memoir, will be found in Appendix M 3 to this report.

LEVEES OF THE MISSISSIPPI RIVER.

In reply to an inquiry from the chairman of the Committee on Commerce of the Senate as to the probable cost of building and repairing the levees of the Mississippi in the States of Louisiana, Mississippi and Arkansas, with the view of protection from overflow, an estimate was prepared by Brevet Brigadier General H. L. Abbot, major corps of engi-

neers, to whom the subject was referred. This estimate and his report will be found in Appendix M 4, in which I fully concur.

IMPROVEMENT OF THE OHIO RIVER.

In charge of W. Milnor Roberts, United States civil engineer, and temporarily of Brevet Major General G. Weitzel, major of engineers.

The survey of this river, referred to in the last annual report as being in progress, has been completed. The whole distance from Pittsburg to Cairo has been found to be nine hundred and sixty-seven miles, two hundred and seventy-one miles of which was surveyed between the years 1836 and 1844. The results of the survey are comprised in one hundred and eighteen charts, drawn to a scale of one thousand feet to the inch, which contain very valuable information, as well in the interest of commerce as for navigation. Work upon the riprap dams, for the improvement of the low-water navigation has progressed satisfactorily, though in some instances it was retarded by the high stage of water. Contracts were made for dams at three of the most difficult points below Cincinnati, and the work upon them will be commenced as soon as the necessary preparation can be made. There are several points below Louisville where improvement is urgently required. A system of lights to aid navigation at the Grand Chain is recommended by the engineer in charge, and land marks at other points he considers desirable. The operations of the snag-boats have been somewhat retarded by the high water; they have, however, performed very satisfactory work in the removal of obstructions to navigation caused by wreck, stumps, logs, &c.

Certain parties representing the interests of Bridgeport, Ohio, opposite Wheeling, having made representations respecting the injury which they anticipated would be done to Bridgeport by the construction of the proposed dam at the head of Wheeling Island, across the Ohio Channel, the engineer in charge was instructed to defer the construction of the dam until an examination of the locality could be made at a low stage of the river. The report of the engineer in charge upon the subject will be found in Appendix N 1.

Citizens of Marietta, Ohio, having also remonstrated against the erection of the dam, as proposed, at that place, a report upon the subject was also required of the engineer in charge. (See Appendix N 2.)

The engineer in charge estimates for continuing the improvement of the river during the next fiscal year, $389,000. (See Appendix N.)

IMPROVEMENT OF THE PATAPSCO BELOW FORT MCHENRY, AND OF THE SUSQUEHANNA BELOW HAVRE DE GRACE.

Officer in charge, Brevet Brigadier General J. H. Simpson, colonel corps of engineers; assistant, First Lieutenant William R. Livermore, corps of engineers.

1. *Improvement of the Patapsco.*—The work of widening and deepening the new cut or Craighill Channel was vigorously prosecuted last year, till the first of November, when the three dredges were removed to the upper entrance of the Brewerton Channel, where they were efficiently engaged until the 10th of December, when, on account of rough weather, they were withdrawn. Operations were resumed this year, June 4, on the Craighill Channel, and at the date of this report it has been completed from Seven Foot Knoll to a little below Belvidere Shoals, with a width of two hundred feet and depth of twenty-one feet below mean low water.

Amount available July 1, 1868	$3,982 84
Allotted from appropriation of 1868	17,000 00
Allotted from appropriation of 1869	27,000 00
Total	47,982 84

Amount expended during the fiscal year	$26,056 65
Amount required to widen the Brewerton Channel to a width of two hundred feet and a depth of twenty-two feet, from Fort McHenry to its intersection with the Craighill Channel	168,900 00
Required for the fiscal year ending June 30, 1871	75,000 00

(See Appendix O.)

2. *Improvement of the Susquehanna below Havre de Grace.*—The deflector at the mouth of the river was stiffened and replaced in November, but was broken by a severe storm one week afterwards. The officer in charge renews the recommendation for a permanent structure of detached cribs of timber and stone at an estimated cost of about $40,000, from which might be deducted the available value of the timber now on hand in the deflector, say $8,000.

Amount available July 1, 1868	$13,500 95
Allotted from appropriation of 1868	5,000 00
Allotted from appropriation of 1869	1,000 00
Derived from sales of property during the year	534 40
Total	20,038 35

Expended during the fiscal year	$18,725 85
Required for the fiscal year ending June 30, 1871	32,000 00

(See Appendix O.)

CONSTRUCTION OF THE DELAWARE BREAKWATER, DELAWARE; AND IMPROVEMENT OF THE HARBOR AT MARCUS HOOK, PENNSYLVANIA.

Officer in charge, Lieutenant Colonel C. S. Stewart, corps of engineers.

1. *Delaware Breakwater.*—From July 1, 1868, to June 30, 1869, labor has been hired by days' work, owing to the failure of the contractor. The first contractors for stone filled their contract on the 6th of October, 1868. Under a new contract, made September 12 of that year, stone was delivered in the following October. During the fiscal year 9,040 tons of stone for the superstructure have been put in place, and 9,271 perches of small stones thrown in to protect the foot of slopes and fill holes in bed, at the extremities of the works; 217 running feet of the superstructure have been completed, at the east end of the breakwater, and 281 at the corresponding end of the ice-breaker. It is expected that the work will be completed this season.

Expended during the year	$80,797 57
Available for the year ending June 30, 1870	62,901 70

(See Appendix P.)

2. *Harbor of Marcus Hook, Pennsylvania.*—The platforms have been placed on two cribs, completing the wood-work for two piers, and two cribs have been sunk in position. One of these has not yet been entirely

filled with rubble stone. It is expected to begin the construction of the stone superstructure for two piers this season, and it is supposed the four piers may be completed during the year. No appropriation is asked.

Expended during the year ending June 30, 1869	$9,039 73
Available for year ending June 30, 1870	59,021 35

(See Appendix P.)

HUDSON RIVER IMPROVEMENTS, AND REMOVAL OF OBSTRUCTIONS IN NEW YORK HARBOR.

Officer in charge, Brevet Major General John Newton, lieutenant colonel of engineers, assisted by Brevet Lieutenant Colonel John M. Wilson, and First Lieutenants A. M. Miller and A. N. Lee, corps of engineers.

Hudson River.—During the fiscal year ending June 30, 1869, the new dikes at Cedar Hill and Cow Island have been completed, costing, respectively, $49,970 77 and $30,475 13. The former is 5,739 feet long, and the latter 3,960. The effect of these dikes has been to increase the depth of water over Cedar Hill Bar from 7.5 to 9.2 feet. Cedar Hill Bar was formerly a serious obstacle, and it is now supposed that little or no dredging will be required.

A contract was made in the spring of 1868 for the removal of the old State dam, located just below Cedar Hill. Owing to failure of contractor, the work was carried on by hired labor. Four thousand cubic yards of stone, sand, and timber have been removed, and the remaining debris so scattered that probably no further removal will be required.

The contract for removing the face of Mull's Island has been completed. One hundred and fifty-eight thousand cubic yards were removed during the working season of 1868.

The Coeymans dike has been prolonged along the face of Mull's Island for 1,640 feet, and it is expected that this dike will be extended so as to connect with the New Baltimore dike during the present season:

Widening the channel between Barren and Mull's Islands has not only increased the flow of water, but has also increased the depth of water in the channel along the upper part of New Baltimore dike.

It is expected that still greater improvement will be effected by the projected dredging at the Coeymans Crossover, and in front of the New Baltimore dike.

General Newton anticipates the necessity for some changes in the plan of the New Baltimore dike, a strong and substantial structure 5,900 feet long, built by the commissioners of the State of New York; but before indicating any modifications, will observe the effects of the present works and contemplated dredging at Mull's Island and Coeymans Crossover.

Cuyler's dike has been prolonged 1,664 feet, to deflect the current and throw it into the proper channel leading towards Overslaugh dike.

At Roah Hook a dike has been constructed to deflect the water into the eastern channel at Barren Island. It has a length of 1,814 feet, and cost at the rate of $10 10 per linear foot. At Parda Hook a dike has been commenced to deflect properly the current over Cedar Hill Bar, and protect the shores. The extension of this dike rendered it necessary to dredge a new channel; and a contract for this purpose has been made. An extension of the Castleton dike northward has also been commenced, and will be completed during the present working season.

Amount available July 1, 1868, of appropriations of 1866, 1867, for improving Hudson River	$179,395 96
Amount expended during year ending June 30, 1869, including amount retained for internal revenue	161,616 59
Amount available July 1, 1869	17,779 37
Amount allotted from general appropriation for repairs, &c., approved July 25, 1868	85,000 00
Amount allotted from general appropriation for improvement, &c., approved April 10, 1869	89,100 00
Total available July 1, 1869	191,879 37
Amount required to complete the improvement of Hudson River according to plan submitted	466,402 11
Amount necessary to be appropriated	274,522 74
Amount required for next fiscal year, and which can be profitably expended	$100,000 00
To dredge and keep open the channel between Albany and Troy will probably require an annual expenditure of about	20,000 00

The permanent improvement of that section of the river is considered by the engineer officer in charge of doubtful practicability. (See Appendix Q.)

Hell Gate, East River, New York.—After the allotment of $85,000 had been made, July 31, 1868, from the general appropriation for river and harbor improvements, approved July 25, 1868, new surveys of Frying Pan and Pot Rock were at once undertaken in order to determine the amount of rock to be removed to give a depth of twenty-five feet at mean low water. Proposals were invited, and a contract for the removal of these rocks was awarded to Mr. Sidney F. Shelburne, the lowest bidder. After many delays, and some modifications in his machinery, the contractor commenced work upon Frying Pan Rock on or about the 15th of January, 1869. Several holes were drilled into the rock, but the machine was finally laid aside by the contractor with a view to constructing another of greater capacity. The time of the contract for the removal of these rocks was extended to August 15, 1869, but up to the close of the fiscal year no real progress had been made in the work.

On the 11th May, 1869, an additional allotment of $178,200 was made for the East River from the general appropriation for the improvement of rivers and harbors, approved April 10, 1869. A contract was then made with Maillefert & Co. for the removal of Pot Rock, Way's Reef, and Shelldrake, at the rate of $44 28 per cubic yard. For the further improvement of the navigation at Hell Gate the engineer officer in charge submitted a project for the removal of Hallett's Point, and also one for the removal of the channel rocks. At the close of the fiscal year initiatory steps were accordingly taken towards the prosecution of this portion of the work. Surveys have been made of Pot Rock, Frying Pan, and Way's Reef in Hell Gate, and also of a great part of Diamond Reef.

Amount allotted from general appropriation of July 25, 1868	$85,000 00
Amount allotted from general appropriation of April 10, 1869	178,200 00
Total	263,200 00
Amount expended to June 30, 1869	6,135 62
Amount available July 1, 1869	257,064 38

The work now in progress will absorb all the available funds. The amount which can be profitably expended during the next fiscal year is $400,000. (See Appendix Q 1.)

Improvement of the harbor of Rondout, Hudson River, New York.—Under a resolution of the House of Representatives of the 28th January, 1869, information was required in reference to the improvement of Roundout Harbor, New York. To comply therewith Brevet Major General Newton was directed to submit a project for this improvement, with an estimate of cost. He recommends a system of dikes to direct the down currents of Rondout Creek and of the Hudson in such a manner as to insure the co-operation of both in the transport of silt away from the mouth of the harbor, and thereby maintain a navigable channel of sufficient width. Some dredging might likewise be necessary. He estimates that to insure the full permanent improvement of which the locality is susceptible, and to secure a depth of water from thirteen to fourteen feet at mean low water, would require an expenditure of $132,665 56. (See Appendix Q 3.)

Removal of the wreck of the steamer Scotland in New York Harbor.—An appropriation of $100,000 was made July 25, 1868, for the removal of the wreck of the steamship Scotland, situated in the south channel of New York Harbor, near Sandy Hook. Proposals were advertised for, and a contract awarded September, 1868, to the Neptune Submarine Company, of New York, the lowest bidders, for the sum of $63,300, and all the rights of the United States to the vessel and cargo. The company commenced operations on the 23d September, and in April, 1869, the officer in charge caused a survey to be made of the progress of the work. The results of this survey, although not allowing of the payment to the contractors of any portion due upon the contract, was satisfactory, and showed that real progress had been made upon several portions of the wreck.

NOTE.—The first section of the wreck has been removed and paid for since the commencement of the present fiscal year. (See Appendix Q 5.)

Bridge proposed to be built between the cities of New York and Brooklyn.—The act of March 3, 1869, establishing a bridge and post route across the East River, made it the duty of the Secretary of War, to determine whether said bridge, when built, will conform to the prescribed conditions of the act, not to obstruct, impair, or injuriously modify the navigation of the river. A commission of three officers of the corps of engineers was constituted by order of the Secretary of War, to report

First. Upon the plan and location of the bridge and practicability of the structure.

Second. What effect the piers and tower foundations and abutments

will have upon the navigation of the river, upon its regimen, and upon the approaches to the harbor of New York.

Third. To what extent the bridge will obstruct or interrupt the passage of vessels and the free access to the United States navy yard at Brooklyn.

Fourth. And such other facts and views as might be found to have an important bearing upon the question, whether the said bridge when built will conform to the prescribed conditions of the act of Congress relating to it.

This commission met in the city of New York and made a report, which was submitted, with recommendations from this office, to the Secretary of War, May 31, 1869, who approved the views and recommendations of the commission, as well as those of the chief of engineers, and the plan of the bridge as proposed by the New York Bridge Company, with the provision that the height of the center of the main span of the bridge shall not be less than one hundred and thirty-five feet in the clear at mean high water of the spring tides; and that, further, the structure shall conform in all other respects to the conditions recommended by the commission.

The report of the commission, with the letters from this office upon the subject, will be found in Appendix Q 4.

IMPROVEMENT OF PROVIDENCE AND PAWTUCKET RIVERS, RHODE ISLAND, AND THAMES RIVER, CONNECTICUT; REMOVAL OF MIDDLE ROCK, NEW HAVEN HARBOR AND WESTPORT HARBOR, CONNECTICUT; SURVEYS OF CONNECTICUT RIVER AND BRIDGEPORT HARBOR, CONNECTICUT.

Officer in charge, Brevet Colonel D. C. Houston, major corps of engineers.

1. *Improvement of Westport Harbor, Connecticut.*—Nothing has been done in this harbor, as the amount of appropriation for the work, \$2,500, is entirely inadequate. The recommendation of an appropriation of \$10,000 made last year is renewed. (See Appendix R.)

2. *Removal of Middle Rock, New Haven, Connecticut.*—The work of removing this rock has not been renewed for want of funds. It is estimated that \$10,000 will complete the removal to the depth originally intended, seventeen feet at low water. The entire removal of the obstructions at the entrance to this harbor requires not only the removal of Middle Rock, but also that of Southwest Ledge, and of two intermediate rocks. On the Southwest Ledge there are six and a half feet at low water, and on the other rocks thirteen feet and fourteen feet, respectively.

To secure a depth of seventeen feet on Middle Rock will require	\$10,000 00
To remove the Southwest Ledge to same depth	30,000 00
To remove the intermediate rocks to same depth	25,000 00
Total required for "removing rocks in New Haven Harbor"	65,000 00

(Appendix R.)

3. *Survey of Connecticut River from Hartford to its mouth.*—The plan recommended for the improvement of the river between these points is to deepen the water on the bars by dredging or scraping. It is esti-

mated that the sum of $70,000 will suffice to give a depth of eight feet as the lowest water, and that the sum of $10,000 expended annually will suffice to maintain this depth. (Appendix R.)

4. *Improvement of Thames River, Connecticut.*—The work on this river has consisted in deepening the channel below the city of Norwich to obtain a depth of fourteen feet at high water. It is expected that this will be completed during the present working season, and that a sufficient balance will be left to enable an examination to be made next season for the purpose of ascertaining the effects of the work. No estimate is submitted for the fiscal year ending June 30, 1871. (Appendix R.)

5. *Improvement of Providence River, Rhode Island, at "the Crook."*—No work has been done on this river during the year. The engineer in charge reports that the sum of $10,000 per annum could be advantageously applied in dredging the channel of this river below the Fox Point wharf.

Required for the next fiscal year, $10,000. (Appendix R.)

6. *Improvement of Pawtucket River, Rhode Island.*—The small balance remaining on hand at last report has been expended in dredging. To complete the work deemed necessary, viz: dredging to obtain a channel six feet deep at mean low water, will require an appropriation of $15,000, which amount is required for the next fiscal year. (Appendix R.)

7. *Survey of Bridgeport Harbor, Connecticut.*—A resurvey of this harbor was made last year, and from a careful study of the changes in the harbor that this survey has developed it is not deemed by the engineer in charge necessary to recommend the construction at this time of any works of improvement. The channel and harbor facilities are essentially as good as shown by the survey of 1837. The channel at its present depth is an artificial one made by dredging. That it remains unchanged as to depth is evidence that no serious injury has been sustained. It is doubtful whether there is any permanent remedy for the evil anticipated by those interested in this harbor. The effect of storms on the sandy bottom of a shoal harbor is necessarily to shift the channel more or less, and if it should be found in future that the channel is not maintained by the action of the tidal currents it will be necessary to excavate as was formerly done. (See Appendix R and R 1.)

8. *Plymouth Beach, Massachusetts.*—This work was in charge of Brevet Major J. A. Smith, captain corps of engineers, until June 1, 1869. Two hundred lineal feet of substantial crib-work of timber covered with plank, and one hundred and seventy-five feet of triangular work, similar to that before used, were completed last autumn. One crib one hundred feet long was framed and another partly built, neither of which could be put in position, owing to the unusual inclemency of the season and the attendant expense. The beach is greatly exposed to the action of the sea, owing to the unfinished condition of those works intended for its preservation. A projet and estimate will be made as early as practicable for the preservation of the beach, upon which the existence of the harbor depends.

Amount allotted to this work from appropriation for repairs of harbors on the Atlantic coast	$7,500 00
Amount expended during the fiscal year ending June 30, 1869	7,423 39

(See Appendix R.)

PRESERVATION AND IMPROVEMENT OF BOSTON HARBOR; PRESERVATION OF THE HARBOR OF PROVINCETOWN; IMPROVEMENT OF THE HARBOR OF NEWBURYPORT, AND SURVEY OF THE MERRIMAC RIVER.

Officer in charge, Brevet Major General J. G. Foster, lieutenant colonel corps of engineers, assisted by Brevet Lieutenant Colonel G. L. Gillespie and Brevet Major George Burroughs, captains corps of engineers.

1. *Dredging off the southwest point of Lovell's Island.*—The work has been carried on steadily by the contractor, who removed 66,909.54 cubic yards, widening the channel to 600 feet at the 16-feet curve, with an average depth of 16½ feet. By the close of the season it is expected that this depth will be increased to 23 feet. (See Appendix S.)

2. *Dredging channel across the Upper Middle Bar.*—Four hundred and fifty cubic yards of material have been removed. The work has been suspended and the amount heretofore allotted for this work has been transferred to the dredging at Lovell's Island. (See Appendix S.)

3. *Blasting and removing Corwin Rock.*—This rock and an adjoining ledge has been entirely removed to a depth of 23 feet at low water. 1,356 tons of rock have been blasted; 1,192 tons deposited on shore, and 164 tons allowed to remain in deep water. The channel formerly between this rock and Tower Rock has been widened by the removal of these rocks from 250 feet to 600 feet. (Appendix S and S 1.)

4. *Blasting and removing Barrel Rock.*—A survey of this rock was made as well as contracts for its removal, and the preliminary preparations for active operations This rock has since been removed. (See Appendix S.)

5. *Sea-wall at Point Allerton.*—The title to the land for the site of the wall (forwarded in January last) has not received the approval of the Attorney General yet; as soon as this is obtained, proposals will be invited for the construction of the wall. (See Appendix S.)

6. *Sea-wall at Gallup's Island.*—This work has steadily progressed; 558 feet of foundation and 456 feet of wall has been built. (See Appendix S.)

7. *Sea-wall for the preservation of the North Head of Long Island.*—The jury of the county court has determined upon the amount to be paid by the United States for the site of this wall, and the fortifications to be erected there. As soon as this amount is paid, either to the owners or to the judge of the court, (according to an act of the legislature of Massachusetts,) and the title receives the approval of the Attorney General, preparations for active work will be made.

Estimates for the fiscal year ending June 30, 1871, for continuing the preservation and improvement of Boston Harbor, a portion of which should be made available for the present fiscal year:

For dredging at Lovell's Island, to complete the work....	$75,000 00
For sea-wall at Gallup's Island, to complete	60,000 00
For dredging at Upper Middle Bar........................	100,000 00
For sea-wall at Point Allerton, to complete................	40,000 00
For sea-wall at Long Island............................	40,000 00
For contingencies.......................................	15,000 00
Total..	330,000 00

8. *Preservation of Provincetown Harbor.*—At Beach Point a brush bulkhead and jetties have been constructed which are fast gathering the floating sand. A dike to guard against any possible breach by the sea through the outer beach has been constructed across the Salt Meadows and East Harbor Creek at High Head. The current and tidal observations in the immediate charge of Captain George Burroughs, brevet major United States Army, have been completed. An allotment of $9,000 from the appropriation of 1869 was made for the construction of certain works for the preservation of the harbor urgently needed, which will be expended this season.

Amount required to be appropriated for the fiscal year ending June 30, 1871, $25,000. (See Appendix S and S 2.)

9. *Merrimac River.*—Surveys have been made of the obstructions in this river, and a report with estimate of cost of removal submitted. (See Appendix S and S 3.)

SEA-WALLS AT GREAT BREWSTER, DEER, AND LOVELL'S ISLANDS, BOSTON HARBOR.

Officer in charge, Brevet Major General H. W. Benham, colonel corps of engineers.

1. *Great Brewster.*—The work of the fiscal year comprised the setting of the heavy shell-stone paving in rear of the whole of the most exposed portion of the east face of the North Head, about 700 running feet; filling the rear of about 400 feet of other portions with earth, covered in the most exposed parts with small bowlders as a temporary protection against the dash of the sea, and the construction of a strong stone pile jetty to protect the west corner of the wall of South Head. It is expected that at the close of the present working season all the work remaining to be done for the complete protection of the North Head, together with two or three jetties at the angles, will be finished, so that all that now appears necessary for the protection of the island will be completed this season, and no further appropriation for this object will be required.

Amount on hand July 1, 1868	$547 85
Allotted from appropriation of July 25, 1868	10,000 00
Allotted from appropriation of April 10, 1869	25,000 00
	35,547 85
Expended during the fiscal year	8,625 87
Amount available July 1, 1869	26,921 98

(See Appendix T.)

2. *Deer and Lovell's Islands.*—Upon the sea-wall at Deer Island 1,250 running feet of the wall of the North Head had been rebuilt and repaired up to the close of the present fiscal year, (June 30,) making in all about 2,210 running feet of wall rebuilt on the three bluffs of the island since 1865. All the most exposed parts of this wall are now repaired. The engineer in charge recommends as an additional security that some 200 or 300 feet of the North Head wall be rebuilt at a cost of about $8,000. At Lovell's Island a strong but small wall of about 800 feet in length, with four jetties at the angles, has been built to protect the southeast bluff, which appear to answer the purpose and to increase the breadth of the beach in front of it. An apron facing of stone, protected by concrete, has been constructed in front of the eastern half of the old wall

Some further repairs and a new jetty are recommended at a cost of about $2,000.

Amount on hand July 1, 1868	$50,515 30
Expended during the fiscal year	43,245 16
Amount available July 1, 1869	7,270 14

(See Appendix T.)

IMPROVEMENT OF HARBORS IN THE STATE OF MAINE.

Officer in charge, Brevet Brigadier General George Thom, lieutenant colonel of engineers.

1. *Saco River improvement.*—These improvements consist in the rebuilding of some of the most important piers in the river, the removal of the sunken rocks, and the construction of a breakwater at the mouth of the river. On the 30th of June, 1869, the sunken rocks had all been removed from the channel near Little Islands, and the breakwater at the mouth of the river had been partially built for a distance of 4,000 feet out from the shore, containing $51,223\frac{85}{112}$ tons of stone. The first 2,550 feet of this breakwater is built up to a general level of nine feet above mean low water, with an average thickness of twenty feet, the remaining portion forms but the "core" of the work to be built, and is barely sufficient to divert the channel as required, or to withstand the violent storms to which it is exposed. This work in its present unfinished condition has accomplished all that was expected from it. It has closed the old North Channel, (as was intended,) and formed a new one, (as was desired,) which is deeper, much more uniform and direct along the inside of the breakwater as far out as it extends, and it is apparently improving beyond that point. To complete this work in a proper manner, it must be increased throughout in height and thickness, and extended. The additional amount required for the *completion* of all the improvements proposed at this time (exclusive of the capping of the breakwater estimated for in previous reports) is $60,000, which amount can be profitably expended during the fiscal year, ending June 30, 1871. (See Appendix U.)

2. *Extension of the breakwater and improvement of the harbor at Portland, Maine.*—The capping of the unfinished portion of the breakwater has been completed, in all $733\frac{1}{2}$ lineal feet. Under a joint resolution of Congress, approved June 5, 1868, the harbor has also been improved by dredging a channel through the "Spit," near the "middle ground," in which there are now twenty feet of water at mean low water, or twenty-nine feet at mean high water. A contract has also been made for excavating a new channel through the "middle ground bar," to be completed on or before the first of November, 1869, and it is probable that it will be completed in that time.

On hand July 1, 1868	$79,397 87
On hand July 1, 1869	64,491 82

Which amount will be expended by the close of this working season in deepening the channel.

For finishing the breakwater, an additional sum will be required of $40,000.

(See Appendix U, U 1 and U 2.)

3. *Improvement of the Kennebec River, between Gardiner and Augusta, Maine.*—This work consists in straightening and deepening the channel of the river, by dredging through several shoals and the removal of rocks which obstruct it between Gardiner and Augusta, Maine. The width of the channel estimated for is one hundred feet at bottom, with sides having a slope of two feet to one foot rise, and a depth of seven feet up to Hallowell, and six and one-half feet thence to Augusta, at low tide in the lowest stages of the river, being about twelve feet at high tide in the same stages. The channel has been completed through Hallowell and Shepard's Point Shoal (at and below Hallowell) to a width of 75 feet, and is in progress to the same width through Britt's Shoal, above Hallowell, which will probably be completed before the 1st of October, 1869. The channel through Gage's Shoal will, it is probable, be more than half completed during the present season. About thirty bowlders have also been removed from the river at Shepard's Point, Hallowell and Britt's Shoals.

The additional amount required to complete the channel from Gardiner to Augusta, (through Hinckley's Shoal and the unfinished portion of Gage's Shoal,) and to increase the width of the new channel throughout to one hundred feet, is estimated at $22,500. (See Appendix U.)

4. *Improvement of the navigation of the St. Croix River, above the ledge.* For this improvement it will be necessary to deepen its channel by the removal of slabs, edgings, and sawdust which for thirty years and more have been accumulating in large quantities in this river.

The act making an appropriation for this improvement requires the co-operation of the province of New Brunswick, which has not yet been obtained, so that operations have not yet been commenced.

Amount appropriated for this work........................	$15,000 00
Additional amount required for its completion............	35,000 00

It being understood that the province of New Brunswick will contribute an equal amount for this purpose. (See Appendix U.)

5. *Survey and improvements at Richmond's Island, Cape Elizabeth, Maine.*—A survey of this locality has been made, with a view to forming an estimate of the probable cost of a breakwater to connect the island with the main land. Such a breakwater would form a good harbor of refuge, affording safe anchorage and good holding ground, with the wind from any point between north and southwest, affording refuge to vessels prevented by northeast storms from entering Portland or adjacent harbors. The breakwater to be permanent should be built of rubble stone, of which the engineer in charge estimates that there will be required 68,000 tons. This, when placed in the structure, would cost $93,000.

Amount which can be profitably expended during the fiscal year ending June 30, 1871, $50,000. (See Appendix U.)

6. *Improvement of the "Gut" Back River, opposite the city of Bath, Maine.*—Owing to the contraction of the channel of Back River at the upper Hell Gate, the tidal current runs through this gate with such violence as to endanger the navigation at any other time than at high and low water, except for steamers. The difficulties are still further increased by a large rock, known as "Boiler Rock," which lies in mid-channel some seventy-five yards below the gate. The engineer in charge examined this rock with the aid of a submarine party. It lies in from three to four fathoms water at low tide, its highest point being only about three feet below the surface at mean low water, and ten feet below

it at high water. For the improvement of navigation at this place, the engineer in charge recommends—

1. Boiler Rock to be removed to a depth of twelve feet, requiring seventy cubic yards of blasting, which, at $50 per cubic yard, would cost	$3,500 00
2. The point of ledge contracting the channel at Upper Hell Gate to be blasted off, requiring about 1,500 cubic yards, at $4	6,000 00
3. Deepening the bar about midway between Upper Hell Gate and Arrowsic bridge, so as to afford a channel one hundred feet wide and ten feet deep at mean low water, requiring 11,000 cubic yards of dredging, which, at fifty cents per cubic yard, would cost	5,500 00
Add ten per cent. for contingencies	1,500 00
Total required for the proposed improvement	16,500 00

All of which could be profitably expended during the fiscal year ending June 30, 1871. (See Appendix U.)

7. *Survey and improvement of the Penobscot River, Maine.*—This survey has been completed. Very extensive and accurate soundings and borings made in the river show that from Crosby's Narrows up to Bangor, a distance of some three and a half miles, the bed of the river is seriously obstructed with slabs, edgings, and sawdust, to an average depth of ten feet, and in some localities more than eighteen feet; and that the harbor of Bangor is also obstructed with several large sunken rocks. To restore the channel to the original river bed would require an excavation of more than 5,000,000 cubic yards of its accumulations. But a passable channel could be made at a cost estimated at from $100,000 to $500,000, according to its width and depth. (See Appendix U.)

8. *Improvement of Union River, Maine.*—A careful examination of this river, from its mouth to Ellsworth, has been made. The engineer in charge estimates that for the improvement of the navigation between these points, by clearing it of slabs, edgings, and sawdust, removing boulders and sunken rocks, and erecting five stone beacons, there will be required an appropriation of $40,000, which, in view of the large lumber trade, he recommends to be made. (See Appendix U.)

RIVERS AND HARBORS ON THE PACIFIC COAST.

Officer in charge, Brevet Lieutenant Colonel R. S. Williamson, major corps of engineers, assisted by first Lieutenant Wm. H. Heuer, corps of engineers.

1. *Improvement of the Willamette River, below Portland, Oregon.*—The operations on this river during the past fiscal year have been confined to dredging on Swan Island Bar, and the bar at the mouth of the river, and to removing snags at each of these localities. Surveys were made of the Willamette slough and of the mouth of the river. Many difficulties were encountered causing delays in the prosecution of the work. In December, 1868, when the dredging was temporarily suspended, a channel had been cut over Swan Island Bar, admitting vessels drawing fifteen feet, during the low water stage. The total length of channel excavated since the commencement of the work in 1867, at this locality,

is 3,200 feet. The estimate of the cost of deepening Swan Island Bar to eighteen feet was based on the supposition that the cost of dredging at a depth between fifteen and eighteen feet would not vary materially from the cost of the previous dredging.

From a report received from the officer in charge, it appears that the dredging at this place has been greatly retarded during the summer by numbers of large, sunken trees imbedded in the bar, the removal of which has been found to consume much time, besides causing frequent breaks in the machinery. For these reasons he deems it advisable to increase his estimate of the amount required for the fiscal year ending June 30, 1871, as follows:

For Swan Island Bar	$25,000 00
For keeping open the channel at the mouth of the Willamette River	6,000 00
Total	31,000 00

which he believes will complete the work on the Swan Island Bar, and keep open the channel at the mouth of the river up to that date.

Amount of appropriation and allotments for the improvement of Willamette River	$79,500 00
Amount available July 1, 1869	26,923 74
Amount required to be appropriated	31,000 00

which can be profitably expended during the fiscal year ending June 30, 1871. (See Appendices V V 1 and V 1, *a*.)

2. *Removal of Blossom Rock in the harbor of San Francisco.*—After the allotment of $50,000 had been made from the general appropriation of 1868 for rivers and harbors for the removal of this rock, the work was advertised and proposals invited. Only one proposal was made, and that being unsatisfactory was rejected. A plan for the removal of this rock was submitted to the officer in charge, accompanied by an offer to remove it to a depth of twenty-four feet at mean low water for $75,000, no payment to be made until the satisfactory completion of the work.

This offer has been accepted, and the officer directed to enter into contract in accordance with the foregoing terms.

Amount allotted from appropriation of 1868	$50,000 00
Amount allotted from appropriation of 1869	25,000 00
	75,000 00

(See Appendices V and V 3.)

SURVEYS AND EXAMINATIONS ON THE PACIFIC COAST.

1. *Survey of the Upper Columbia River, Oregon.*—Portions of the Upper Columbia River, Homly Rapids, and Rock Creek Rapids, have been examined with a view to ascertaining the position and dimensions of certain rocks, and to preparing estimates of the probable cost of removal of these obstructions. (See Appendix V.)

2. *Harbor of San Pedro, (Wilmington,) California.*—An examination of this locality has been made with a view to preparing a project for the improvement of the harbor. The report of the officer in charge, with estimate of the probable cost of improvement, is transmitted herewith. (See Appendices V and V 2.)

SURVEYS AND EXAMINATIONS WITH THE VIEW TO THE IMPROVEMENT OF RIVERS AND HARBORS.

The following estimates of appropriations showing the amounts required for the purpose of making further surveys and examinations of localities, the improvement of which has been heretofore, or that may be hereafter authorized, were submitted in my last annual report; and there having been no appropriation made for this purpose, the estimates are again submitted.

For the Atlantic coast	$30,000 00
For the Pacific coast	25,000 00
For the western and northwestern rivers	125,000 00

WORKS IN THE DISTRICT OF COLUMBIA.

PUBLIC BUILDINGS, GROUNDS, AND WORKS, IN THE DISTRICT OF COLUMBIA.

Officer in charge, Brevet Brigadier General N. Michler, major corps of engineers.

For the condition of the public buildings, grounds, and works, and recommendations for their further improvement, see the report in detail of the officer in charge. His estimate for the next fiscal year is—

For the improvement, care, and repair of public buildings, grounds, and works, in the District of Columbia	$584,192 00
For compensation of persons employed on and about public buildings, grounds, and works, as above	49,002 00
Total	633,194 00

(See Appendices W and W 2.)

WASHINGTON AQUEDUCT.

A report in detail upon the condition of this work will be found in Appendices W and W 1.

The officer in charge submits estimates for the fiscal year ending June 30, 1871, as follows:

For continuing the construction of the distributing reservoir	$200,000 00
For completing unfinished work and for superintendence and repairs	188,190 00
Total	388,190 00

BISHOP'S CANAL LOCK.

By authority of the Secretary of War a board of engineers was detailed February 21, 1867, to examine the model of an improved canal and ship lock submitted by Mr. Martin Bishop, of Ohio. The report of this board will be found in Appendix W 3.

SURVEY OF NORTHERN AND NORTHWESTERN LAKES.

Lieutenant Colonel and Brevet Brigadier General W. F. Raynolds, corps of engineers in charge, assisted by Captain and Brevet Lieutenant Colonel F. M. Farquhar until the month of November, 1868;

by Lieutenant J. F. Gregory during the entire year; by Lieutenant B. D. Green until April, 1869; by Lieutenants E. H. Ruffner, J. C. Mallery, and W. E. Rogers during the entire year; by Lieutenant L. M. Haupt until January, 1869, and by Lieutenant J. E. Griffith until April, 1869.

Captain and Brevet Major J. A. Smith reported for duty on the survey in the month of June, 1869.

In addition to the above-named officers of the corps of engineers, General Raynolds was assisted by Messrs. D. F. Henry, O. N. Chaffee, J. R. Mayer, and H. Gillman, as principal assistants. Messrs. Chaffee and Gillman tendered their resignations, and did not enter upon the field-work in the season of 1869. They were succeeded by Messrs. A. C. Lamson and O. B. Wheeler, principal assistants.

During the season of 1868 the operations of the survey were carried on by the three steamers belonging to the lake survey and five shore parties on Lake Superior; three astronomical parties, one at Ogdensburg, one at Watertown, and one at Oswego, in the State of New York; three gauging parties, measuring the outflow of the rivers St. Clair, Niagara, and St. Lawrence; thirteen meteorological observers at different localities on the lakes; two draughtsmen, reducing maps for publication; two assistants, in office and attending to chart distribution; three assistants, engaged in reducing meteorological observations, &c.

During the season 1869, in consequence of the late date at which the act of partial appropriation of funds was passed by Congress, the field force was reduced proportionately, and the operations of the survey progressed with the following organization, namely, two steamers and two shore parties, six astronomical and triangulation parties on Lake Superior, and two river gauging parties on the rivers St. Clair and Niagara.

The stations for the primary triangulation of Lake Superior have been selected. This duty involved an examination of heights near the shore, and as they are all covered by a dense growth of forest trees, the amount of labor required for selection was far greater than would have been the case in a region under cultivation.

General Raynolds expresses the opinion that the reconnaissance leaves but very little doubt that a system of triangles can be obtained that will cover the entire lake.

The off-shore hydrography of the northern coast has been completed, and the greater portion of that of the southern coast will be completed this season.

A portion of the general hydrography as well as a portion of the primary triangulation will remain incomplete, the season having proved unfavorable for field operations far worse than hitherto known in the history of the survey.

The district of Isle Royale embraces numerous harbors and anchorage grounds which have never been used, and many dangers to navigation which have been discovered during the survey. A chart of the district will be prepared exhibiting all the features of the locality, which will be of essential benefit to navigation.

The district extending from the western end of Isle Royale to the extreme western end of the lake presented many difficulties not met with in more favored localities, due to the almost entire isolation, to the absence of harbors, and to a great extent of even boat landings, and to the rough, mountainous country, covered by a dense growth of forest trees. The survey of this district has been completed successfully without an accident.

The survey of the district at the head of St. Mary's River and north-

ward, and including the triangulation of the large bay south and west of White Fish Point has been completed.

The survey of Lake St. Clair was resumed after the surveying parties had been withdrawn from Lake Superior, and considerable progress made.

In addition to the ordinary duties of the lake survey, it became necessary to detach portions of the surveying parties to make minute local examinations and surveys connected with the improvements of harbors and rivers, in some of which the use of the steamers was unavoidable. Among these local surveys the dredged channels at St. Clair Flats and in St. Mary's River, at Lake George, and that of Maumee Bay required the aid of steamer.

Maps of the above surveys were made as well as copies of manuscript maps of previous surveys, and supplied to the officers of engineers requiring their use. The meteorological observations at twelve stations have been continued, and the reductions and computations incident thereto have been made, but the means of the reductions, &c., only have been incorporated in this report.

The distribution of charts has been continued at the offices in Detroit and Buffalo. The number issued exceeds that of previous years very largely, with the exception of that of the year preceding.

A detailed chart of the survey of Huron Bay and Huron Islands, Lake Superior, has been reduced and is now in the hands of the engraver.

A series of charts, three in number, covering the entire Lake Superior, are in progress, and await the completion of the primary triangulation.

A preliminary chart of the east end of the lake, similar to that of the middle portion, has been issued to meet the wants of commerce until the finished and more perfect charts of the same region are prepared for engraving and publication.

A general map of the entire chain of lakes, on a scale of one twelve hundred thousandth, has been commenced.

The unusually unfavorable season for the field-work has prevented the completion of the survey of Lake Superior, as was confidently anticipated at the period of submitting the last annual report. The failure in receiving the large theodolites, manufactured in Berlin and imported for the primary triangulations, has also contributed in some measure to delay the completion of the survey of this lake.

The amount of the last appropriation, together with the amount made available of the partial appropriation of 1867 withheld, but reappropriated, aggregating $150,000, will be exhausted by the close of the fiscal year, June 30, 1870.

The estimated amount required for continuing the survey during the year ending June 30, 1871, is $159,000. (See Appendix X.)

RECONNAISSANCES AND EXPLORATIONS.

Officers of engineers have been on duty at most of the headquarters of the military divisions, departments, and districts, where they are charged with the preparations of detailed maps and sketches required by the commanding general, and with the collection of topographical information requisite in the compilation of the military maps engraved and distributed by the Engineer Department. The following officers have been thus serving, namely: Major Henry M. Robert, at the headquarters military division of the Pacific; Brevet Colonel W. E. Merrill, division of

the Missouri; Brevet Major W. J. Twining, department of Dakota; Brevet Major C. W. Howell, department of Missouri, who was succeeded by Brevet Captain C. B. Phillips; Brevet Captain L. C. Overman, fifth military district, who succeeded Lieutenant L. M. Haupt, resigned; Lieutenant M. B. Adams, department of the Platte, who succeeded Lieutenant R. W. Petriken, resigned; Lieutenant George M. Wheeler, department of California. In addition to the above, Captain C. W. Raymond was temporarily assigned to duty in the division of the Pacific for the purpose of an exploration of the Yukon River, Alaska, some eight hundred or nine hundred miles above its mouth.

COLORADO OF THE WEST.

The continuation of the exploration of this river above Calville, Utah, has been postponed in view of the enterprise now in progress under the direction of Professor Powell, the results of whose examinations may have an important bearing upon the further survey of the river, if indeed it should be undertaken. The rapid examinations made by Professor Powell in descending the river may show that little or no practical value will result from the attempt to improve the portion of the river hemmed in within the deep cañons extending from a point somewhat above the junction of the Green and Grande rivers, forming the Colorado River, to a point not far above Calville, on the Colorado.

Below the latter locality it may be important to the mining region in southern Nevada to offer better facilities of communication by way of the river than are now possessed. The results of Lieutenant G. M. Wheeler's exploration, now in progress from the White Pine Mines to the head of navigation on the Colorado, may furnish the necessary information in relation to this subject.

FROM SIERRA NEVADA TO THE ROCKY MOUNTAINS.

The geological and topographical exploration of the territory between the Sierra Nevada and the Rocky Mountains, including within its limits the route or routes of the Pacific Railroad under the direction of Mr. Clarence King, has been successfully conducted by him. He reports the results of the exploration subsequent to the close of the last season's operations as follows:

The topography and geology eastward to Salt Lake have been nearly completed; five latitude stations well connected with the system of triangles have been established; three good longitude stations are completed. The topographical and geological work at the close of last season covered a belt one hundred miles wide and over five hundred miles long. The results furnish the proof of a geological unity of structure in the whole zone of ranges west of Salt Lake.

During the winter Mr. King and his assistants were occupied with the reduction of the field work, the examination of ores, &c., and the preparation of the reports. In the spring of this season he resumed operations on the Promontory, Tangent, and Wasatch ranges, and the survey of Salt Lake. The party will move eastward and complete the survey of the hills as far as the Green River divide. The closing labors of the party, Mr. King reports to be especially fruitful in valuable results: first, in relation to the extent of the coal formation; secondly, in the data bearing upon the question of the great Cordillera mountain system; thirdly, in the evidences of immense glacier systems in the Uintah Mountains, and of coincidence with the greater European mountain chains. The collections in natural history are rich and complete.

MISCELLANEOUS.

MAPS OF TERRITORIES, MILITARY DEPARTMENTS, AND DISTRICTS.

The recompilation of the map of the territory between the Mississippi River and the Pacific Ocean has been completed, and the map has been extensively distributed. The information obtained from surveys and reconnaissances made since the preparation of the present edition of the map will be promptly compiled and reduced for engraving, and a new edition will be issued. The changes will be mostly embraced in Nevada, Utah, and Arizona Territories, although additional information is expected from most of the military departments and districts where surveys of reservations and military routes are in progress under the direction of the officers at the headquarters of these departments and districts. The limited means at the disposal of these officers have restricted them to ordinary reconnaissances of the country, rather than absolute surveys.

A new map, covering the entire territory of the United States between the Atlantic and Pacific Oceans, has been compiled and engraved, designed both for military and geographical purposes. The map, in the former sense, indicates the military departments, districts, and posts. The want of a map of this character has been felt for a long time, and it is believed that this want will be satisfactorily met by this map.

MAPS OF CAMPAIGNS AND BATTLE-FIELDS.

The preparation of the campaign maps has been in progress, and the engraving of portions of them has been completed, and of others is in progress.

Brevet Brigadier General Michler is charged with the preparation of the maps of the campaigns of the armies of the Potomac and James, and Colonel Edward Ruger, late of the volunteers, with those of the western armies. The re-survey of the battle-field of Gettysburg, Pennsylvania, has been commenced, and has progressed satisfactorily. (See Appendix Y.)

ESTIMATE OF SURVEYS FOR MILITARY DEFENSES.

There will be required for continuing the surveys relating to permanent sea-coast defenses, explorations, surveys, and reconnaissances in the interior, and the collection of topographical and other information of the country occupied by military forces, for the compilation, engraving, printing, and distribution of maps, including campaign maps, the sum of $200,000.

OFFICE OF THE CHIEF OF ENGINEERS.

In the labors of the office I have been assisted by the following officers in charge of its five divisions:

FIRST DIVISION.—*Fortifications, &c.*, Lieutenant Colonel J. D. Kurtz, brevet colonel United States Army.

SECON DIVISION.—*Battalion and depots, lands, armaments, personnel, &c.*, Major T. L. Casey, brevet colonel United States Army.

THIRD DIVISION.—*River and harbor improvements, &c.*, Major J. G. Parke, brevet major general United States Army.

FOURTH DIVISION.—*Property, accounts, estimates, funds, &c.*, Major W P. Craighill, brevetlieutenant colonel United States Army.

FIFTH DIVISION.—*Survey of the lakes, explorations, maps, instruments, &c.*, Lieutenant Colonel I. C. Woodruff, brevet brigadier general United States Army.

ON SPECIAL DUTY.—*Experiments relating to iron shields and counter-poise gun carriages*, Captain W. R. King, brevet major United States Army.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers,
Commanding Corps of Engineers.

The ADJUTANT GENERAL *of the Army.*

APPENDIX.

APPENDIX A.

Extract from the annual report of Brevet Colonel J. B. Wheeler, corps of engineers, upon the lake harbor improvements in his charge.

UNITED STATES ENGINEER'S OFFICE,
Milwaukee, Wis., August 31, 1869.

GENERAL: I have the honor to submit this my annual report of the operations and progress of the works under my direction, for the fiscal year ending June 30, 1869.

* * * * * * * * *

In the amounts reported as unexpended on June 30, 1869, at each harbor, I give the sums due the harbor from the appropriations and allotments, as shown by my books at that date. Of course there were liabilities incurred previous to that date which reduce these amounts considerably.

* * * * * * * * *

In conclusion, I would again urge the great importance to these harbors of consistent and uniform action in appropriating money for these works. I would, therefore, repeat the remarks made on this and other subjects in my report for 1868.

During the year I was relieved by Brevet Lieutenant Colonel Farquhar, captain of engineers, in obedience to orders from the Chief of Engineers, of November 10, 1868, of the works on the eastern shore of Lake Michigan, in the State of Michigan, excepting New Buffalo. By orders of the same date, Captain Mackenzie was relieved from duty with me.

Captain Cuyler reported to me in December, 1868, and was assigned to the charge of the harbors of Superior City, Ontonagon and Eagle Harbor, in place of assistant Henry Bacon, who resigned his position to resume the practice of his profession in Indiana. With these exceptions the organization of my office and duties of my assistants remain substantially the same as heretofore given. Annexed is an abstract of all contracts made by me during the fiscal year ending June 30, 1869; also a recapitulation of the amounts required for completion, and for the next fiscal year. It is well to state that the word *completion* is relative, meaning the completion of a given plan.

My sincere thanks are due to the General commanding, and the officers at the headquarters of the corps of engineers, for the promptness always shown in replying to my requests and requisitions.

All of which is respectfully submitted.

J. B. WHEELER.
Major of Engineers, Brevet Colonel, and Superintending Engineer.

Major General A. A. HUMPHREYS,
Chief of Engineers, &c.

Abstract of contracts made during the fiscal year ending June 30, 1869.

Place and contractor.	Labor and materials.	Price.
SUPERIOR CITY, WIS.		
R. G. Coburn, May 15, 1869	Twelve-inch square timber, per lineal foot	$0 20
	Plank and scantling, per thousand, (B. M.)	16 00
	Brush or slabs, per cord of 128 cubic foot	3 00
	Stone ballast	11 00
	Pile timber, per lineal foot	12
	Framing timber, per lineal foot	20
	Driving piles, per lineal foot of timber driven	13
	Iron drift bolts, per pound	....
	Iron spikes, per pound	....
ONTONAGON, MICH.		
Eugene F. Prince, November 27, 1868.	For removing 455 piles (more or less) on east side of channel	2,690 00
	For removing sunken cribs (4 or 5 in number)	3,000 00
	For 12-inch square timber, per lineal foot	14
	Pine plank, per thousand (B. M.)	15 00
	Brush, per cord of 128 cubic feet	5 50
	Driving piles, each	5 00
	Removing and putting stone in pier, per cord	1 75
	Framing timber, per lineal foot	18
EAGLE HARBOR, MICH.		
George W. Townsend, January 26, 1869.	Blasting and removing rock, per cubic yard	40 00
MARQUETTE, MICH.		
Hart & Jennings, June 18, 1869	Twelve-inch square timber, per lineal foot	20
	Iron drift bolts, per pound	05
	Stone ballast, per cubic yard	1 23
	Framing timber, including placing, sinking, and filling cribs	14
GREEN BAY, MICH.		
William Richardson, August 8, 1868.	Dredging, per cubic yard	30
William Richardson, May 15, 1869.	Furnishing dredging machine, tug-boat, dump scows, at per day of 10 hours' work	140 00
Smoke & Shuette, June 18, 1869	Twelve-inch square pine timber, per lineal foot	14
	6 by 12-inch pine timber, per lineal foot	09
	Pile timber, (Norway pine,) per lineal foot	11
	Iron drift bolts, per pound	05
	Iron screw bolts, per pound	12
	Stone ballast, per cord of 128 cubic feet	10 00
	Brush, per cord of 128 cubic feet	2 50
	Framing timber, per lineal foot	14
	Driving piles, each	1 50
	Cutting off and leveling piles, each	30
	Putting tenons in plate timbers, each	75
MANITOWOC, WIS.		
John Shuette, May 28, 1869	Dredging, per cubic yard	20
David Smoke, May 26, 1869	Twelve-inch square pine timber, per lineal foot	15
	Twelve-inch square hemlock, per lineal foot	14
	Pine plank, per thousand (B. M.)	14 00
	Oak plank, per thousand, (B. M.)	20 00
	Pile timber, per lineal foot	15
	Stone ballast, per cubic yard	1 75
	Brush, per cubic yard	30
	Framing timber, including placing, sinking, and filling cribs, per lineal foot	17
	Driving piles, each	2 50
	Removing old cribs, each	60 00
Joseph Vilas, June 5, 1869	Wrought-iron drift bolts, per pound	04½
	Wrought-iron spikes, per pound	06½
SHEBOYGAN, WIS.		
John Silbernagel, October, 23, 1868.	Stone ballast, per cord of 128 cubic feet	8 75
Harrison Barrett, October 23, 1868.	Stone ballast, per cord of 128 cubic feet	8 75
S. M. Barrett, June 23, 1869	Twelve-inch square timber, per lineal foot	20
	Framing timber, including placing, sinking, and filling cribs, per lineal foot	16
	Stone ballast, per cord of 128 per cubic feet	8 00
	Brush, per cord of 128 cubic feet	3 00
	Wrought-iron bolts, per pound	04½

Abstract of contracts, &c.—Continued.

Place and contractor.	Labor and materials.	Price.
RACINE, WIS.		
Fred. M. Knapp, June 10, 1869.	Three-inch pine plank, per thousand (B. M.)	$15 00
	Four-inch pine plank, per thousand (B. M.)	15 00
	Twelve-inch square pine timber, per thousand (B. M.)	18 33
	Wrought-iron bolts, per pound	04
	Wrought-iron spikes, per pound	06
	Framing timber, per lineal foot	10
	Removing timbers of old pier, per lineal foot	02
	Driving sheet piles, per running foot of pier	1 50
	White oak, or Norway pine piles, per lineal foot	24
	Driving round piles, each	5 00
	Putting government stone into cribs, per cord	4 00
	Bowlder stone, per cord of 128 cubic feet	13 50
	Rubble stone, per cord of 128 cubic feet	12 50
	Dredging, per cubic yard	35

Amount of the estimated cost of the completion of the several lake harbor improvements under the superintendence of Brevet Colonel J. B. Wheeler, major of engineers, together with the sums asked for the next fiscal year.

No.	Name.	Nature of the work.	Amount required to complete the work.	Sums asked for the next fiscal year.
1	Superior City, Wis	Extension of piers	$155,300 00	$75,000 00
2	Ontonagon, Mich	Extension of piers	238,780 00	80,000 00
3	Eagle Harbor, Mich	Excavation of rocks and construction of piers.	196,294 00	....
4	Marquette, Mich	Construction of breakwater	273,130 00	91,000 00
5	Green Bay, Wis	Cutting new channel	17,500 00	17,500 00
6	Manitowoc, Wis	Extension of piers and dredging	31,000 00	31,000 00
7	Sheboygan, Wis	Extension of piers	34,000 00	34,000 00
8	Milwaukee, Wis	Extension of piers	54,000 00	54,000 00
9	Racine, Wis	Extension of piers	40,000 00	40,000 00
10	Kenosha, Wis	Repairing piers and dredging	40,000 00	40,000 00
11	Chicago, Ill	Extension of piers	45,000 00	45,000 00
12	Michigan City, Ind	Extension of piers, dredging, and sheath piling.	....	....
13	New Buffalo, Mich	Dredging new cut	....	....
		Total	1,125,004 00	607,500 00

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MILWAUKEE, WIS., *December* 24, 1868.

GENERAL: I have the honor to acknowledge the receipt, on the 22d instant, of your letter of December 17, inclosing two communications from Mr. David Quinn, dated, respectively, November 25 and December 5, 1868, with instructions from you "to report all facts relative to the work, with amount and character of work done" at Eagle Harbor, Lake Superior.

A contract was made with David Quinn, of Chicago, on the 10th day of August, 1867, to remove the rock from the entrance to Eagle Harbor, so as to obtain a depth of not less then fourteen (14) feet at low water. The work to be commenced on or before the 1st day of September, 1867, and finished by October 1, 1868. The engineer's estimate was eighteen hundred and three (1,803) cubic yards to be removed. The advertisement calling for proposals stated that it was "situated in the middle of the entrance, included within an area of two hundred and sixty (260) by one hundred and thirty (130) feet, and in a depth of water not less than ten (10) feet." A copy of this contract, with the advertisement attached, is on file in your office.

At the time of bidding, and at other times when asked for, a copy of the map of Eagle Harbor, with this area, above mentioned, marked upon it, was shown to all persons desirous of knowing the location of the work. I am under the impression that Mr. Quinn was furnished with a tracing of this map, but have no record of the fact or his asking for it.

Upon examining the records of this office I ascertain, from Mr. Bacon's letters to me and Mr. Quinn's letters, the following dates and facts, viz: That Mr. Quinn was at Eagle Harbor on the 10th of September, 1867, apparently to examine the locality, and did not notify Mr. Bacon, the assistant engineer in charge of this harbor, that he was to be there at that time. On the 24th of September, assistant Bacon writes from Eagle Harbor, that the contractor is not there, and gives his idea of the magnitude of the work.

Mr. Bacon writes again from Eagle Harbor, on the 29th of October, that "Mr. Quinn had not as yet settled on his plan of operations," and recommends a remeasurement of the work. It appears that Mr. Quinn had returned to Eagle Harbor, leaving Milwaukee, Wis., on October 24th, and met Mr. Bacon on the 29th of October, 1867, at Eagle Harbor.

On the 30th of November, Mr. Bacon writes that as soon as ice is firm enough that Mr. Quinn would try surface blasting; that Mr. Quinn has no fixed plan of operations; and that "Mr. Quinn's operations must of necessity be, for the first, in a measure experimental."

On the 24th of January, 1868, Mr. Quinn had returned to Eagle Harbor, and on the 26th Mr. Bacon was there. On the 8th of February, Mr. Bacon transmitted a report, giving in detail the measurements of the work, calculations of the amount to be excavated and the exact location of the ranges, by which Mr. Quinn could work. He states that the ice did not form sufficiently strong until the latter part of January for him to make the survey required. At the same time he reports the want of success in surface blasting, as tried by Mr. Quinn.

This failure of the surface blasting and the survey was reported by me to headquarters on February 13th. On February 9th Mr. Bacon left Eagle Harbor.

Mr. Quinn appears to have abandoned all surface blasting during this month of February, and commenced the experiment of drilling holes in the rock and charging them with explosive compounds.

Mr. Bacon writes on the 2d of March that Mr. Quinn writes him that "he is succeeding beyond his most sanguine expectations." In a letter to me of February 24th, Mr. Quinn states the same thing. On the 25th of March Mr. Bacon writes that the ice had broken up, and Mr. Quinn had left Eagle Harbor to procure machinery, &c., for drilling these holes by steam.

In his report of March 31st Mr. Bacon refers to Mr. Quinn having wasted the greater part of February in his experiments of surface blasting, both with powder and nitro-glycerine. He reports very favorably upon the experiments made in drilling holes and charging them with nitro-glycerine. He reports having measured 100 cubic yards of loose rock removed, and recommends payment for this amount.

From this time to the latter part of May, 1868, nothing was done.

Under date of June 22d Mr. Bacon reports Mr. Quinn at work; waiting for nitro-glycerine; and notices an absence of any matured plan of operations on the part of Mr. Quinn.

On the 3d of August Mr. Quinn left for New York to see about his nitro-glycerine, that was still delayed. At this point we may consider the work as stopped by Mr. Quinn.

Under date of September 30th Mr. Bacon writes that, in his opinion, the cause of Mr. Quinn's failure was his over-confidence, making him undervalue the magnitude of his work, and says that "in June Quinn thought the work more than half done," but that he (Bacon) thought that not more than one-seventh had been done.

In November I sent Mr. Bacon to Eagle Harbor to measure up the work done, and under date of November 19th he reports 197 cubic yards of loose rock and gravel and 20 cubic yards of broken rock removed—in all, 217 cubic yards. Also from 400 to 450 holes drilled; which, allowing an average depth of four feet each, would give 1,800 feet of drilling done. This drilling can be done for one dollar and twenty-five cents per foot. Allowing him this liberal estimate, Mr. Bacon thinks that he has been paid in full for what he has done, in which I agree. The 217 cubic yards, at $58, would amount to $12,586; the 1,800 feet of drilling, at $1 25, would amount to $2,250; total $14,836.

Mr. Quinn has received 90 per cent. of his contract price on 300 cubic yards, or $15,660. These payments being made respectively on May 13, July 24, and September 10, 1868, on estimates of Mr. Bacon.

I append to this letter a copy of Mr. Bacon's report to me for November, with a summary of the season's work, that was prepared without any reference to the matter now before us, that goes over the whole ground, and is in itself a complete answer to your letter of December 17. The foregoing facts and Mr. Bacon's reports are sufficient, without my attempting to reply to Mr. Quinn's communications.

In my opinion Mr. Quinn has failed to do the work, in consequence of ignorance and misapprehension of what he had to do, combined with a want of means or ability to procure sufficient funds to carry on the work under a systematic and well matured plan of operations. And I also think that he has been paid in full for all labor performed at Eagle Harbor, and that it would be wrong and unjust, even to Mr. Quinn himself, to extend the time of his contract.

I am, general, very respectfully, your obedient servant,

J. B. WHEELER.
Major of Engineers and Brevet Colonel.

Major General A. A. HUMPHREYS,
Chief of Engineers, &c.

P. S.—Mr. Quinn's letters to you are herewith returned.

Eagle Harbor monthly report for November, 1868; *being also the report for the close of the season.*

ONTONAGON, MICH., *December* 7, 1868.

SIR: In making the regular monthly report for November, 1868, I will combine the report required by your letter of October 1, 1868, for the close of the working season.

During the month of November, 1868, no work has been done or attempted at Eagle Harbor by the contractor, Mr. Quinn. His contract time expired on the 1st day of October, 1868, and his application for an extension of time has been refused by the Chief of Engineers. The work has been advertised to be re-let December 30, 1868, by advertisement dated October 12, 1868. This course will probably secure the completion of the work one or two years sooner than to leave it in the hands of Mr Quinn, and at a largely reduced cost.

By your orders, I left Ontonagon on the 6th of November, 1868, and arrived at Eagle Harbor the next day, and remained there till November 19, then left for Ontonagon, and arrived November 22.

During this visit at Eagle Harbor, I made as careful measurement and cross-sections of the proposed channel, in squares of ten feet, as was practicable; the results of which I transmitted to you under date of November 19, 1868. I will make those results, and the accompanying table of cuttings and calculation of contents, a part of this report, with the following extract from my letter of November 19, 1868:

"I have completed the cross-sectioning of the proposed channel at this place, and will transmit the results of the measurements and calculations herewith.

"There has been only two days since the day of my arrival (November 7) when anything could be done which would approach to accuracy.

"My soundings were all made on the 12th and 18th of the present month. They are approximately accurate, but if the remaining excavation is to be let by the cubic yard, I would recommend a resurvey to be made when the ice is frozen to work on.

"I made these soundings from a raft of about forty feet length, which we tried to hold in place with anchors and poles, but I could not do better than a close approximation to position. I would say that the estimate is sufficiently accurate for a settlement with Mr. Quinn, as the work of drilling done must be taken into the account to give him title to the pay already drawn, which could not have been drawn at all under a strict construction of the contract. The results show 217 cubic yards of rock removed. This is nearly all loose rock and pebbles; I would not estimate twenty yards of broken rock removed. The *value* of the 217 yards, compared with the whole work, is certainly not over 66⅔ per cent. in proportion, these being equal to 145 yards. There are, perhaps, 400 to 450 holes drilled, averaging not over four feet each, or 1,800 feet. The highest estimate of the cost of such drilling is $1 25 per foot. Very many of these holes will be found useless in the progress of the work."

I send the pay-rolls for the labor I have employed on the survey, amounting to $47. The contract with Mr. David Quinn for excavating the rock was executed August 10, 1867; the work having been assigned to him as the lowest responsible bidder, July 31, 1867. It was to begin by September 1, 1867, and be completed October 1, 1868. Mr. Quinn made two visits to Eagle Harbor during the season of 1867, but did no work, and made no *preparation* for work before the close of navigation. Very little could have been done excepting during about three weeks in October 1867, when the weather was very favorable. His plan, at the close of the season, was to work on the ice during the frozen season. He had no materials or machinery, such as drills, drilling machinery, powder, nitro-glycerine, &c., and it was impracticable to get a drilling machine, the nitro-glycerine, or the proper quality of powder, before the opening of navigation in 1868.

As soon as the harbor was well frozen, in January, 1868, I made an accurate survey and soundings on and near the proposed channel, in order to determine the best location, and quantity of excavation. The survey and calculations were completed February 8, 1868 and I would here refer to the plan, table, and calculations, as reported under that date. From these results it was determined to locate the channel to be excavated, 80 feet wide, being from 25 feet to 105 feet, west of the Target range, and sections 10 to 17 inclusive. This would require 2,040 cubic yards of rock excavation.

Mr. Quinn was present during the survey, and prepared to test his

theory that the rock could be blasted by powder exploded on the surface. He had caused some experiments to be made in 1867, without any perceptible effect, and it was again manifest that he might as well explode powder on the water surface. Six or eight kegs of powder produced no perceptible effect on the rock. He exploded ten pounds of nitro-glycerine on the surface of the rock in about ten feet of the water with the same result. He then abandoned the plan on which he had depended, and proceeded to drilling. This he was obliged to do in the most primitive manner, with hammers first, and then spring poles. The ice season proved unusually short, lasting only from the latter part of January to about the 10th of March. He had a large force of men for a short time, drilling and grappling the loose rock. When the ice broke up, about 200 or 300 lineal feet of holes had been drilled, and about 100 cubic yards of the rock removed. He was then paid for 100 cubic yards of excavation at $58 per yard, less ten per cent.—$5,220.

Nothing more was done to the work till June, 1868. Mr. Quinn then began drilling, with a good face, with spring poles, on rafts. No blasting was done in June, as he had made up his mind that nothing but nitro-glycerine would answer the purpose, and he could not obtain that, although it had been promised to be shipped from New York as early as May 15. Nitro-glycerine is undoubtedly preferable to powder, but powder could be made to do the work, as the rock is not difficult to drill or fracture. No blasting was done till about July 9, when Mr. Quinn obtained sixty pounds of nitro-glycerine from a mining company, at an enormous cost, and exploded about fifty cartridges in holes scattered without system, most of them being in the deeper parts of the excavation. As might have been expected, the results were not very satisfactory, although it proved the power of the explosive. Common sense would indicate that it would be better to begin blasting on a system to obtain a *face*. But all the drilling has been done at hap-hazard, trusting in the power of the oil to blow the rock to atoms, without system. Some of the charges produced a good effect, though in most cases the rock seems to be crushed, but not sufficiently broken to allow its ready removal.

Mr. Quinn continued the work of drilling and picking up loose rock, with a diminished force, till about the middle of August, when all work was finally discontinued. He left, in pursuit of nitro-glycerine, August 3, and I have heard nothing directly from him since.

On the 16th of July, 1868, 100 cubic yards of excavation was reported, and 90 per cent. has been paid, $5,220, making the total payments $10,440.

Neither of the payments could have been made under a strict construction of the contract, but both were made at Mr. Quinn's urgent request, to assist in continuing the work.

In my opinion these payments cover the full value of all the work done, estimating the whole job at $58 per cubic yard. The season of 1868, from early in May to the middle of August, was one of the most favorable that has been observed since the settlement of the country. Since the middle of August it has been extremely unfavorable.

I am sorry to report so little work accomplished, and have indicated the causes of failure.

Very respectfully, your obedient servant,

HENRY BACON, *Assistant.*

Colonel J. B. WHEELER,

Major of Engineers U. S. Army, Milwaukee, Wisconsin.

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HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., December 9, 1868.

GENERAL: In compliance with the request of the Hon. T. W. Ferry, member of Congress, and with your approval, Brevet Colonel J. B. Wheeler, corps of engineers, was directed in June last to make a survey of the harbor of Charlevoix, Michigan, and submit a plan for its improvement, with an estimate of the cost, &c. The survey has been completed and the report presented, a copy of which is herewith submitted. The estimated cost of the improvement of the harbor is, in round numbers, $200,000, and Colonel Wheeler remarks that "from the location of the harbor, and the width of channel that we are obliged to adopt in improving it, I am of the opinion that the interests of commerce do not require this place to be made a harbor of refuge."

The views of Colonel Wheeler are concurred in.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen'l of Engineers, Commanding.

Major General J. M. SCHOFIELD,
Secretary of War.

MILWAUKEE, WISCONSIN, *October* 28, 1868.

GENERAL: I have the honor to transmit herewith a tracing of the map made of Charlevoix Harbor, with a plan and estimates of the cost of improving this harbor, prepared under the instructions from the headquarters of the corps of engineers, of June 18, 1868.

This survey and the estimates were made under my direction by M. T. Casgrain, who has compiled all the information necessary to a full understanding of the advantages and the difficulties of improving this harbor, in the accompanying report.

It will be seen from this report that it will be possible to improve a channel only one hundred feet wide, and to do this the estimated cost will be $198,044 14—nearly $200,000.

From the location of this harbor, and the width of channel that we are obliged to adopt in improving it, I am of the opinion that the interests of commerce do not require this place to be made a harbor of refuge.

I am, general, very respectfully, your obedient servant,

J. B. WHEELER,
Major of Engineers and Brevet Colonel.

Major General A. A. HUMPHREYS,
Chief of Eng's, Com'g Corps of Eng's, U. S. A., Washington, D. C.

OFFICE UNITED STATES ENGINEERS,
Milwaukee, Wis., August 19, 1868.

COLONEL: I have the honor to submit the following report and estimates on Charlevoix Harbor, (Pine River,) Michigan, from the survey made, through your orders, between July 10 and 16, 1868.

PINE RIVER.

This river empties itself in Lake Michigan, between Little and Grand Traverse Bays. It is a narrow and shallow stream which connects the

waters of Round and Pine Lakes with those of Lake Michigan. From mouth of river to Round Lake is one third ($\frac{1}{3}$) of a mile in length, and an average width of seventy-five feet; the depth of water varying from two (2) to six (6) feet; this two (2) feet depth being in the rapids near its mouth, and extending some six hundred feet. The bed of the river is sand, marl, gravel, and clay, mixed together, and stone. From the foot of Round Lake to the entrance of the river into Lake Michigan there is a fall of one foot and sixty-two hundredths (1.62.)

VILLAGE OF CHARLEVOIX.

This small village is situated on the south side of the river. Charlevoix is the county seat of Emmet County, which is fast being settled. Its population is six hundred and thirty (630) inhabitants. It has a post office, two stores, two hotels, a school-house, and a steam saw mill. A pile pier extending some nine hundred feet in the lake was erected by private parties, some three years ago, for the purpose of supplying the lake propellers with cord-wood. The whole of the land bordering on Pine Lake being chiefly timbered with beech and maple, affords special advantages for a considerable wood trade. The soil is rich, being a sandy, calcareous loam, of considerable uniformity. Winter wheat is the staple crop at present, and does well. The peculiar mildness of the fall weather is favorable to its growth, and the snow, which covers the young plant in this region, insures the crop against winter-killing. Fruit, such as apples, pears, peaches, and grapes, grown in more temperate climates, are cultivated here with great success.

ROUND LAKE

Is a small sheet of water half a mile in diameter, with a depth of from thirty (30) to sixty (60) feet. Extensive farms have been cleared along its shore, which present a fine appearance. The head of Round Lake is connected with Pine Lake by a narrow, tortuous, and shallow stream some three-fourths ($\frac{3}{4}$) of a mile in length, about one hundred (100) feet in width, and a depth of four (4) feet. The bed of the river is sand, marl, clay, gravel, and stone. There is a fall of nearly two (2) feet between Pine and Round Lakes, forming a current of about five miles an hour.

PINE LAKE

Lies about one mile east of Lake Michigan, and runs easterly. It is fifteen miles long, and two wide. Six miles from its mouth, on the south side of it, is an arm running southward eight miles, and an average width of half a mile. There is a saw mill at the head of Pine Lake, and a small tug plies upon it. The shores of the lake are rolling, the timber mostly beech and maple, interspersed with elm, hemlock, fir, and some pine. Farms are being cleared up about it; cottages and green fields begin to decorate its margin, adding artificial beauty to the natural loveliness of its surroundings.

Pine Lake stands nearly four (4) feet above Lake Michigan. Its waters are clear and very pure, navigable for vessels of all classes. Its depth varies from sixty (60) feet to one hundred (100) feet free from shoals and bars.

PRESENT IMPROVEMENTS AT THE MOUTH OF RIVER.

These consist only of a pile pier which was built some three (3) years ago. It extends into Lake Michigan to the depth of twenty (20) feet, and is nearly nine hundred (900) feet long. It affords ample accommodations for the present shipping interests.

An attempt was made to open a straight cut eight (8) feet deep across the narrow sand beach, as shown by the line A B on the accompanying sketch, and thus effect a change in the river channel; but owing to the nature of the ground, which is clay and gravel, with scattered bowlders, it was found very expensive, and finally abandoned.

The amount of wood shipped from this point last year was fifteen thousand (15,000) cords; at $3 50 per cord = $52,500.

PROPOSED PLAN AND ESTIMATES FOR THE IMPROVEMENT OF CHARLEVOIX, PINE RIVER HARBOR.

In consequence of the narrow, tortuous, and shallow channel of this river and the hard material to be excavated, together with the bold sand banks which border its sides, it was deemed necessary to limit the width of the channel to 100 feet.

The plan and estimates made and submitted are based on this width, and consist in constructing two parallel piers, extending each 640 feet into Lake Michigan to the depth of 14 feet, and from the eastern extremity of the south pier, with a radius of 410 feet, continue the crib-work 224 feet to the base of the sand-hills at A. The outer end of each pier to have a crib 32 feet by 25 feet by 20 feet.

Dredge a channel 100 feet wide to a depth of 12 feet, and protect both sides of it with close piling. This close piling to commence at the inner end of the crib-work and to extend to the entrance into Round Lake.

A.—*Estimated cost of one crib*, 32 *feet by* 25 *feet by* 20 *feet.*

3,353 feet square timber, at 20 cents per lineal foot	$670 60
288 feet 3-inch plank, board measure, at $15 per M	4 32
3,938 pounds iron bolts, at 10 cents per pound	393 80
6 pounds iron spikes, at 10 cents per pound	60
89 cords of stone, at $16 per cord	1,424 00
10 cords of brush, at $2 50 per cord	25 00
Labor of framing and placing, 3,353 feet, at 20 cents per lineal foot	670 60
	3,188 92
Add 10 per cent. for contingencies	318 89
	3,507 81

B.—*Estimated cost of one crib*, 32 *feet by* 20 *feet by* 17 *feet.*

2,368 feet square timber, at 20 cents per lineal foot	$473 60
288 feet 3-inch plank, board measure, at $15 per M	4 32
3,554 pounds iron bolts, at 10 cents per pound	355 40
6 pounds iron spikes, at 10 cents per pound	60
56 cords of stone, at $16 per cord	896 00

6¾ cords of brush, at $2 50 per cord	$16 88
Labor of framing and placing, 2,368 feet, at 20 cents per lineal foot	473 60
	2,220 40
Add 10 per cent. for contingencies	222 04
	2,442 44

C.—*Estimated cost of constructing* 1,504 *feet of crib-work, or* 47 *cribs, for improving Charlevoix Harbor.*

20 cribs, at $2,442 44 for north pier	$48,848 80
25 cribs, at $2,442 44 for south pier	61,061 00
2 cribs, at $3,507 81 for outer ends of each pier	7,015 62
Total cost of crib-work	116,925 42

D.—*Estimated cost of close piling* 2,466 *feet, to protect the river banks from abrasion.*

For 2,712 piles, 25 feet long = 67,800 lineal feet, at 10 cents per lineal foot	$6,780 00
For 4,932 feet capping 12 inches square, at 20 cents per lineal foot	986 46
For 9,864 feet capping 6 by 12 inches, at 10 cents per lineal foot	986 40
For driving 2,712 piles, at $3 each	8,136 00
For 246 cross-ties, 14 feet long, 12 inches square = 3,444 lineal feet, at 20 cents per foot	688 80
For 1,579 iron bolts, 1 inch square = 12 inches long = 5,337 pounds, at 10 cents per pound	533 70
For 492 screw bolts, 1⅛ inches round, 14 inches long = 1,968 pounds, at 20 cents per pound	393 60
For 2,712 iron bolts, 1½ inches square, 30 inches long = 51,528 pounds, at 10 cents per pound	515 28
For labor of framing and bolting 13,308 feet, at 20 cents per lineal foot	2,661 60
	21,681 78
Add 10 per cent. for contingencies	2,168 17
Total cost of close piling	23,849 95

It was found impossible to determine the precise quantity of hard and soft materials to be excavated in the river and give correct estimates for each. All the earth above water, or dry dredging, is estimated at thirty cents per cubic yard. Below water, taking both the soft and hard material, fifty cents per cubic yard is assumed as a fair price. Separate estimates for each of these are herewith given.

E.—*Estimated cost of dredging the harbor of Charlevoix, Michigan, to place the proposed crib piers, dredge a channel between them, and deepen the river from Lake Michigan to Round Lake a uniform depth of twelve feet.*

To excavate 26,860 cubic yards in Lake Michigan to place 47 cribs, and dredge a channel 100 feet wide between them, at 50 cents per cubic yard	$13,430 00
To excavate 46,881.32 cubic yards to enlarge the river to a width of 100 feet, and deepen it 12 feet, at 50 cents per cubic yard	23,440 66
To excavate 20,336.51 cubic yards of earth above water, at 30 cents per cubic yard	6,100 95
	42,971 61
Add 10 per cent. for contingencies	4,297 16
	57,268 77

F.—*Recapitulation of estimates.*

To build 1,504 feet of crib-work as per estimate C	$116,925 42
To construct 94,077.83 feet of close piling, as per estimate	23,849 77
To dredge 94,077.83 cubic yards of earth, as per estimate	57,268 77
Total cost	198,044 14

Respectfully submitted.

W. T. CASGRAIN.

APPENDIX B.

Extract from the annual report of Brevet Lieutenant Colonel Farquhar, corps of engineers, upon the lake harbor improvements in his charge.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wisconsin, July 1, 1869

GENERAL: I have the honor to submit the following annual report of operations for the works of harbor improvements under my charge for the year ending June 30, 1869.

In obedience to paragraph 3, Special Order No. 152, dated headquarters Corps of Engineers, Washington, D. C., November 10, 1868, I relieved Brevet Colonel J. B. Wheeler, major corps of engineers, of the charge of the works of harbor improvements at the harbors of St. Josephs, South Haven, Grand Haven, Muskegon, White River, Pentwater, Père Marquette, Manistee, and Aux Becs Scies, Michigan.

By virtue of paragraph 5 of the same order, First Lieutenant E. A. Woodruff, corps of engineers, was assigned to duty under my immediate orders.

* * * * * *

In all cases, the general plans for the improvement of the several harbors, submitted by Colonel Wheeler and approved by the Chief of Engineers, United States Army, have been carried out.

There have been some modifications of details which have in all cases, however, been submitted to, and approved by, the Chief of Engineers.

At each harbor there is stationed a foreman, whose duties are to be present at the work during all working hours and see that the contractors comply strictly with all the specifications under which they work, and to take charge of all public property belonging to the work.

* * * * * *

Recapitulation, showing amounts appropriated, amounts unexpended July 1, 1869, *total amount expended on work to June* 30, 1869, *amounts to be expended during fiscal year ending June* 30, 1870, *and amount required for fiscal year ending June* 30, 1871.

Name of harbor.	Total amount appropriated and allotted.	Total amount expended on work to June 30, 1869.	Amount on hand unexpended July 1, 1869.	Amount to be expended during fiscal year ending June 30, 1870.	Additional amount required for fiscal year ending June 30, 1871.
Aux Bees Scies	$140,041 00	$100,895 87	$39,145 13	$39,145 13	$60,000 00
Manistee	60,000 00	49,437 25	10,562 75	10,562 75	70,000 00
Pere Marquette	81,500 00	48,909 74	32,590 26	32,590 26	52,000 00
Pentwater	73,000 00	47,702 45	25,297 55	25 297 55	40,000 00
Mouth of White River	102,000 00	50,326 23	51,673 77	51,673 77	50,000 00
Muskegon	59,000 00	42,687 04	16,312 96	16,312 96	30,000 00
Grand Haven	105,000 00	102,431 98	3,246 92	3,246 92	100,000 00
Black Lake	106,615 31	82,126 72	24,488 59	24,488 59	10,000 00
Mouth of Kalamazoo River	30,000 00	....	30,000 00	30,000 00	75,000 00
South Haven	43,000 00	40,832 44	2,167 56	2,167 56	72,000 00
St. Joseph	29,000 00	28,701 82	521 25	521 25	80,000 00

Abstract of contracts made during the fiscal year ending June 30, 1869.

Name of harbor.	Names of contractors.	Stone, per cord of 128 cubic feet.	Brush, per cord of 128 cubic feet.	Slabs, per cord of 128 cubic feet.	Pine timber.	Oak timber, per lineal foot.	Pine piles.	Oak piles, per lineal foot.	Drawing old piles, per pile.	Drawing new piles.	Plank and scantling, per M., board measure.	Dredging, per cubic yard.	Framing timber and putting in place, per lineal foot.	Wrought-iron screw bolts.	Wrought-iron drift bolts.	Wrought-iron spikes, per lb.	Washers for screw bolts.	For taking stone from place of deposit and putting in work, per cord, 128 cub. ft.	For tearing away of old work, per running foot of pier.
Grand Haven	Heb. Squire and T. Stewart White	$15 00		$2 25	[1]$0 16		$0 07	$0 15	$2 10	[2]$0 07			$0 15	[3]$0 12	[3]$0 06	$0 10		$3 00	$1 75
Muskegon	Granville D. Jennings				[1]11														
Do	do	12 90																	
Do	Hasbrouck & Conro				[5]13										[3]4				
Manistee	Granville D. Jennings				[2]11½														
Do	do	12 90																	
Do	Hasbrouck & Conro				[5]13										[3]4				
Père Marquette	Patrick M. Danaher	13 98	1 49	1 49	[5]12⅓			[6]8		[2]12	$18 00		14		[3]4½				
Aux Becs Scies	Whitwood & Hubbel	17 00	4 50	2 50	[5]17		[7]2 00	[6]7.5	3 00	3 00		$0 35	18						
Pentwater	C. Fitzsimons	12 89																	
Do	Robert Rogers			1 50				[8]24 50			17 00							2 50	
Black Lake	T. Stewart White	12 94	3 70	3 70		[9]$0 24 [10]12		13½		[11]20			14½	[12]6¼	[13]4½		$0 10		

[1] Per cubic foot.
[2] Per lineal foot.
[3] 1¼-inch.
[4] 7-inch.
[5] 12 inches square, per lineal foot.
[6] Elm or Norway.
[7] Elm or Norway, 30 feet long.
[8] Piles, capping pieces, driving pieces, and putting in place.
[9] 8x12 inches.
[10] 4x8 inches.
[11] Per foot D.
[12] 1 inch diameter.
[13] 1⅛ inches square.

Surveys have been made of the mouth of the Aux Becs Scies River, mouth of White River, and the mouth of the Kalamazoo River. The result of these surveys are shown on the sketches attached to the report on each of the localities. A party is now engaged on the surveys of the other harbors under my charge, and as soon as maps can be made copies will be forwarded.

I would respectfully call attention to the fact that when the improvements at a harbor are completed there is no one who is responsible for the proper care of the piers.

Vessels at times in want of ballast will take it from the piers. The piers are used as docks, and ties are broken in being used in the place of snubbing posts to make fast to.

I would suggest that it would be well that a law should be enacted by which the finished portion of the work be placed under the supervision of the collector of customs, who should see that the piers are not used for any private purposes, and who should have power to enforce the collection from vessel owners of amounts expended in repairing damages caused by vessels running to, or tying up to, the piers. There is no reason why this care should be of any extra expense to the government, and would in many cases save the cost of repairing the piers. For the history of the various works under my charge, and the importance of the localities where they are, I would refer to the reports of the Chief of Engineers for 1866, 1867, and 1868.

Under the authority of the Chief of Engineers, a dredge and dump-scows are being built at a cost of $15,500, and a tug will be bought at a cost of $6,000. The cost of this dredging machinery will be distributed as follows:

From amount allotted to improvement of White River Harbor	$8,000
From amount allotted to improvement of Pére Marquette Harbor	4,000
From amount allotted to improvement of Pentwater Harbor	4,000
From amount allotted to improvement of Black Lake Harbor	4,000
From amount allotted to improvement of Saugatuck Harbor	1,500
Total	21,500

I have no doubt that in less than two seasons more that the whole cost of the dredging machinery will be saved by the government dredging with its own machinery.

Could the appropriations for the works of harbor improvements be made in the early part of the winter much money would be saved in the price of the lumber to be used, as a great deal, if not all of it, has to be hauled for some distance, which can be done much more easily when the ground is covered with snow.

I have the honor to be, very respectfully, your obedient servant,

F. U. FARQUHAR,

Captain U. S. Engineers and Bvt. Lieut. Col. U. S. Army.

Brevet Maj. Gen. A. A. HUMPHREYS,

Chief of Engineers U. S. Army, Washington, D. C.

B 1.

AUX BECS SCIES HARBOR, (FRANKFORT.)

The work done at this harbor for the last fiscal year was as follows:

12,641 cubic yards of earth removed from between piers; 114 cords of brush filling put in piers; 382 cords stone filling put in piers; 165 cubic feet of timber furnished.

* * * * * *

Owing to the lateness of the season (1869) work commencing, not much progress was made during the last fiscal year. It will be seen by the accompanying tracing that much of the dredging of last year has again to be done during the present year. May 20, 1869, a contract for doing the work at this harbor was entered into with Messrs. Whitwood and Hubbell. They did not get their dredging machinery in place until the 18th of June. The following are the prices paid:

Timber—pine 12 inches square, per cubic foot	$0 17
Piles—elm or Norway pines, 30 feet long, each	2 75
128 cubic feet for stone, per cord	17 00
128 cubic feet for brush, per cord	4 50
128 cubic feet for slabs, per cord	2 50
For framing, per cubic foot of timber used in construction, the framing to include placing, filling, and sinking of cribs and leveling bottom	18
For driving piles, each	3 00
For dredging, per cubic yard	35

The work proposed for the present season is to carry out the north pier extension 320 feet, to build two short wings to protect inner ends of pile revetments, and to dredge out the channel between the piers to a depth of 10 feet.

To make a good harbor of refuge, (and it is much needed as such,) both piers should be carried out to the 12-feet curve, a further extension of 390 feet, and the channel dredged to a depth of 14 feet, which would cost $60,000.

This amount can be profitably spent during the fiscal year ending June 30, 1871.

Aux Becs Scies, or Frankfort, is in the collection district of Michigan, and the nearest point of entry is Grand Haven.

Its nearest light-house is on Point Aux Becs Scies, or Point Betsie, as it is generally known.

Number of arrivals and departures of vessels and estimates of the amount, kind, and value of imports and exports of Aux Becs Scies Harbor, Michigan, (Frankfort,) from June 1, 1868, *until June* 30, 1869.

ENTERED.			CLEARED.		
Articles.	Quantity.		Articles.	Quantity.	
Provisions	3,625 bbls.	$85, 500	Fish	1,000 half bbls.	$6, 000
General merchandise	20 tons	42, 000	Hides	75	675
Oil	98 cans and 15 bbls.	460	Railroad ties	1,400	350
Dry goods	146 bales and cases.	50, 000	Cedar posts	3,000	300
Millinery	40 cases	1, 000	Wood	300 cords	900
Boots, shoes & leather	50 rolls and cases	6, 000	Bark	39 cords	108
Drugs	200 c's. and 100 cans.	5, 500	Bbls. and axe-helves		100
General hardware	45 tons and 145 kegs.	18, 000	Furs	6 bales	600
Iron and steel	67 tons	5, 360			
Lime	Bbls	1, 250			
Lumber	159,000 feet	7, 000			
Sash and blinds		1, 500			
Hay and feed	150 tons	3, 700			
Cattle	100 head	5, 300			

Number of vessels entered, 300. Number of vessels cleared, 300.

B 2.

MANISTEE HARBOR, MICHIGAN.

The south pier was extended 256 feet, and the north pier 96 feet during the last fiscal year. It is proposed to extend the north pier 160 feet, and the south pier 96 feet during the present season.

* * * * * * * * * *

The contracts for this season's work were let to Granville D. Jennings for framing and furnishing stone, and to Hasbrouck and Conro for furnishing timber and iron.

Abstract of bids received and opened February 23, 1869, for furnishing stone for improving harbor at Manistee.

No.	Names of bidders.	Residence.	Stone.
			Per cord
1	Norton De Clercq & Co	Chicago, Ill	$12 97
2	Carkin & Kimball	Milwaukee, Wis	13 45
3	Hasbrouck & Conro	Milwaukee, Wis	14 50
4	William Callaway	Milwaukee, Wis	18 00
5	W. B. Champion	Chicago, Ill	14 00
6	Thomas T. Langdon	Lemont, Ill	14 90
7	Granville D. Jennings	Fulton, N. Y	12 90
8	Lyman Bridges	Chicago, Ill	13 95

Abstract of bids received and opened January 10, 1869, for improving the harbor at Manistee.

No.	Names of bidders.	Residence.	I. Pine timber 12 × 12 in. per lin. foot.	II. Iron bolts.	III. Stone filling.	IV. Framing per lineal foot of timber.	Remarks.
				Per lb.	Pr. cord.		
1	R. A. Conolly	Chicago, Ill	$0 17	$0 5¾	$14 00	$0 12½	76 cents per cord.
2	Granville D. Jennings	Fulton, N. Y	0 21	0 6	12 90	0 11⅝	
3	Mark V. Thompson	Syracuse, N. Y	0 20.28	0 4¾	15 20	......	
4	Charles J. De Graw	Fulton, N. Y	0 30	0 8	10 00	0 12	
5	Hasbrouck & Conro	Milwaukee, Wis	0 13	0 4	15 00	0 16½	$2 per cord for putting stone in cribs.
6	Larkin & Kimball	Milwaukee, Wis	0 15.9	0 4⅜	14 60	0 13⅞	
7	William Nichols	Detroit, Mich	0 20	0 6	*3 30	0 10	60 cts. per cub. yard for putting stone in cribs.
8	Henry Starke	Milwaukee, Wis	0 16⅜	0 5	13 90	0 14¾	

*Per cubic yard.

Putting stone in cribs constituted part of the labor of framing, and the cost thereof is to be included in the total cost of framing. Charles J. DeGraw declined to enter into a contract to furnish stone, and therefore proposals for furnishing the stone were invited.

Abstract of contracts for improving harbor at Manistee.

Contractors.	Nature of contract.	Price.
Hasbrouck & Conro	12-inch timber, per lineal foot	$0 13
Do	Iron bolts, per pound	0 04
Granville D. Jennings	Framing, per lineal foot of timber	1 11⅝
Do	Stone, per cord	12 90

To complete the improvement of this harbor both piers should be extended, the north 512 feet, and the south 608 feet, beyond what is proposed for this season's work, which would cost $70,000.

The sharp angle on the south side of the channel should be cut away as indicated in the accompanying sketch, and the channel bank should be reveted; which would cost $9,000.

On the sketch the finished work is shown in black, the proposed work for this season in red, and the work for which a new appropriation must be made, if it is to be done, in blue.

Manistee is in the collection district of Michigan, and nearest port of entry is Grand Haven. The nearest light-house in operation is at Grand Point au Sable, twenty miles south of Manistee.

Statement of vessels entered and cleared Manistee Harbor, in the district of Michigan, during the year 1868, showing the numbers, tonnage, crew, and cargoes.

Articles.	Entered.	Articles.	Cleared.
Number of vessels	1,203	Number of vessels	1,179
Number of tons	394,694	Number of tons	235,095
Number of crews	10,535	Number of crews	10,557
Bushels corn	2,710	Feet lumber	10,557,000
Bushels oats	10,646	Feet shingles	7,357,000
Barrels flour	6,785	Railroad ties	1,700
Barrels pork and beef	285	Packages merchandise	318
Bushels potatoes	630		
Packages merchandise	57,176		

B 3.

PÈRE MARQUETTE HARBOR.

During the past fiscal year the north pier was extended 128 feet, and the superstructure of the south pier was completed.

During the present season it is proposed to carry out the north pier, which work will exhaust the amount on hand for improving this harbor, $32,590 26.

* * * * * * * * * *

Abstract of contract for improving harbor at Père Marquette—Patrick M. Danaher.

Timber.—Pine 12 inches square, per lineal foot	$0 12½
Piles.—Elm or Norway pine, per lineal foot	08
For plank and scantling, per 1,000 feet, (board measure)	18 00
For wrought-iron drift bolts, per pound	04½
For stone, per cord, (128 cubic feet)	13 98
For brush and slabs, per cord, (128 cubic feet)	1 49
For framing, including placing, filling, and sinking of cribs, and leveling bottom, per lineal foot of timber used in construction	14
For driving piles, per lineal foot of pile driven	12

This is a most important harbor, and when the improvements proposed by Colonel Wheeler shall have been completed, will be the best harbor of refuge on east shore of Lake Michigan between Grand Haven and Traverse Bay. All of the slab pier on the south side of the entrance to the harbor should be removed and dredged out to the red line shown on accompanying sketch. This would cost $52,000.

After the funds for this season's work were allotted there was no time for advertising, so a contract was made with Patrick M. Danaher, who

has been the actual contractor for all the previous work done at this harbor at the above prices.

Père Marquette is in the collection district of Michigan. The nearest port of entry is Grand Haven, and the nearest light-house is at Grand Point au Sable.

Statement of vessels entered and cleared at Père Marquette, and showing the number and kind of import and export from June 1, 1868, *to June* 30, 1869. *The number of arrivals and departures is about* 600, *including sail and steam.*

Articles.	Export.	Import.
Railroad ties	12,000	Provisions and other mercantile articles for consumption amount to value of $300,000.
Cords of shingle board	4,000	
wood	2,000	
bark	60	
Feet of lumber	20,000,000	
square timber	3,000,000	
shingles	7,000,000	
lathes	5,000,000	
fence pickets	1,000,000	

B 4.

PENTWATER HARBOR, MICHIGAN.

The work done during the past fiscal year was the extending of the south pier 256 feet, and dredging 22,632 cubic yards of earth from between the piers. In consequence of there being no north pier the channel filled up during the winter, so that there was only a depth of water six feet last spring where ten was reported last autumn.

The citizens at their own expense dredged out a channel last spring to a depth of ten feet, and there is now building a north pier 600 feet in length, as shown in blue in accompanying sketch.

To complete the improvement of this harbor the south side of entrance, where the revetment is of slabs, should be dredged away as far as shown by red line in the accompanying sketch. This would cost $40,000.

Owing to want of time for advertising, this work, except the furnishing of stone, was let at an open letting. Robert Rogers is the contractor for the season's work at the following prices, which are very reasonable:

Abstract of contract for improving harbor at Pentwater, Michigan—Robert Rogers, contractor.

For furnishing and framing timbers and bolting, and putting in place, per thousand, board measure, $17.

For furnishing piles and capping pieces, driving piles, and putting on capping pieces, per pile used in construction, $4.

For furnishing piles and putting them in pier, per cord, $1 50.

For taking stone from place of deposit and putting them in pier, per cord, $2 50.

Abstract of bids received and opened June 4, 1869, *for furnishing stone at Pentwater.*

Names of bidders.	Residence.	Price.	Remarks.
Lyman Bridges	Chicago, Ill	$14 75	
G. P. Adams & Co	Chicago Lake	{ 14 00 { 12 00	At $4 per cord, on bridge pier.
C. Fitzsimons	Chicago, Ill	12 89	At $12 on dock, not higher than vessel's rail.

The contract for furnishing the stone was awarded to C. Fitzsimons, at $12 89 per cord.

During the gales of last fall and winter the south pier suffered severely. The superstructure for 32 feet from outer end of pier was carried away, and the adjoining superstructure much damaged. The whole pier has settled very badly, and will require considerable work and expense to repair it. These necessary repairs, together with the building of 600 feet of pier on north side, form the proposed work for the season, and will exhaust the balance yet unexpended on July 1, 1869, ($25,297 55.)

Pentwater is in the collection district of Michigan, and the nearest port of entry is Grand Haven, sixty miles distant. The nearest light-house is at Grand Point au Sable.

Statement of vessels entered and cleared Pentwater Harbor, in the district of Michigan, during the year 1868, *showing the numbers, crews, tonnage, and cargoes.*

Articles.	Entered.	Articles.	Cleared.
Number of vessels	315	Number of vessels	313
Number of tons	25, 783	Number of tons	24, 476
Number of crews	2, 334	Number of crews	1, 459
Bushels corn	1, 962	M lumber	11, 830
Bushels oats	29, 778	M laths	470
Tons hay	788	M shingles	26, 130
Tons feed	2, 430	M pickets	33
Barrels flour	1, 634	M staves	130
Barrels salt	282	Railroad ties	6, 050
Barrels pork and beef	482	Cords wood	548
Bushels potatoes	106	Cords slabs	196
Cords stone	449	Cords bark	16
Tons coal	18	Packages merchandise	1, 490
Packages merchandise	11, 098		

B 5.

MOUTH OF WHITE RIVER, MICHIGAN.

No work except the driving of a few piles was done during the past fiscal year.

* * * * * * * * *

This harbor is in the worst condition of any under my charge. During the winter much of the new channel has been filled up. Until the channel through the new cut is dredged out and the pier to protect it is built, commerce is greatly impeded. None but vessels drawing less than six feet can enter White Lake.

It is proposed for this season's work to dredge out the channel to a depth of ten feet, and protect it by pier carried out to the six-feet curve, and early next spring to complete the pier extension to the twelve-feet curve. Should the weather be good, the north pier may be carried out to the twelve-feet curve during the coming autumn.

A pile driver is now being built for this harbor, and will be completed early in August. It is believed that this work can be done more economically by hired labor, worked under the immediate supervision of the officer in charge of the work, than by the contract system, the materials being purchased in open market. So far the prices paid for material have been more than ten per cent. less than any prices obtained by advertising for proposals, besides securing a much better class of materials.

The amount on hand and in the United States treasury available for this work will be entirely exhausted during the present fiscal year, and to fully complete this harbor, giving a channel at least twelve feet deep,

and extending the piers to the fifteen-feet curve, will require an additional sum of $50,000, which amount can be profitably expended during the fiscal year ending June 30, 1871. White River is in the district of Michigan, and the nearest port of entry is Grand Haven. The nearest light-house is at Muskegon, twelve miles distant.

Statement of vessels entered and cleared White River Harbor, in the district of Michigan, during the year 1868, *showing the numbers, tonnage, crews, and cargoes.*

Articles.	Entered.	Articles.	Cleared.
Number of vessels	666	Number of vessels	666
Number of tons	106,869	Number of tons	52,770
Number of crews	6,912	Number of crews	3,843
Bushels corn	13,259	M lumber	42,944
Bushels oats	25,718	M laths	4,130
Bushels wheat	150	M pickets	162
Tons hay	374	M staves	245
Tons feed	51,500	Railroad ties	21,700
Barrels flour	1,808	Cords wood	776
Barrels salt	335	Cords bark	17
Barrels pork and beef	156	Boxes fish	2,789
Hides	335	Packages merchandise	106
Cords stone	71		
Packages merchandise	48,612		

B 6.

MUSKEGON HARBOR, MICHIGAN.

Two cribs (32 feet by 20 feet) were placed on the north pier extension, and one (32 feet by 32 feet) on the end of south pier, and the superstructure on both piers completed.

* * * * * * * * *

The contracts for this season's work were let to Hasbrouck & Conro for timber and iron bolts, and to Granville D. Jennings for framing and stone.

Abstract of bids received and opened January 10, 1869, *for improving harbor at Muskegon, Michigan.*

No.	Names of bidders.	Residence.	Pine timber, 12×12 inches, per lin. ft.	Bolts, per pound.	Filling stone.	Framing, per lineal foot of timber.	Remarks.
					Per cord		
1	R. A. Conolly	Chicago, Ill	$0 17	$0 05¾	$14 00	$0 12½	*76 cents per cord for putting stone in crib.
2	Wm. Nicolls	Detroit, Mich	20	6	†3 30	10	60 cents per yard for putting stone in crib.
3	Galen Eastman	Grand Haven	14.9	5	†13 70	19¾	
4	Ch. J. DeGraw	Fulton, N. Y	30	8½	9 50	12	
5	Squire E. White	Grand Haven	15½	5½	13 70	14	$50 per crib for leveling bottom; $2 50 per cord for putting stone in crib.
6	Denis Dowling	Muskegon	17	......	†3 50	......	
7	Carkin & Kimball	Milwaukee	16½	4⅝	14 75	14¾	
8	Hasbrouck & Conro	....do	13	4	15 00	16½	$2 per cord for putting stone in cribs.
9	Mark V. Thompson	Syracuse, N. Y	19.2	4⅞	14 88	......	
10	Granville D. Jennings	Fulton, N. Y	21.6	6	12 00	11	

* "Putting stone in cribs" constitutes a part of the labor of "framing," and the cost thereof is to be included in the total cost of framing.

† Per cubic yard.

Abstract of bids received and opened February 23, 1869, for improving harbor at Muskegon.

Name of bidders.	Residence.	Stone, per cord.
Norton de Clercq & Co	Chicago, Ill	$11 98
Carkin & Kimball	Milwaukee	13 45
Hasbrouck & Conro	....do	14 50
W. B. Champion	Chicago, Ill	14 00
George Janssen	Milwaukee	18 00
Thomas F. Langdon	Lemonte, Ill	14 49
Squire & White	Grand Haven	13 76
Granville D. Jennings	Fulton, N. Y	12 90
Lyman Bridges	Chicago	13 95

Abstract of contracts for improving harbor at Muskegon, Michigan.

Contractors.	Nature of contract.	Price.
Hasbrouck & Conro	12-inch timber, per lineal foot	$0 13
Do	Iron bolts, per pound	4
Granville D. Jennings	Framing, per lineal foot of timber	11
Do	Stone, per cord	12 90

During the present working season the north pier will be extended 320 feet, and the south pier will be filled with stone ballast.

A break where the south crib pier joins the slab pier will be repaired.

It will be necessary to repair the slab piering interior of the crib pier, to do which the slabs should be removed to one foot below the water surface, and a crib superstructure should be built, which will cost $28,000.

Unless this work is done there will be continual trouble arising from breaches, and consequently filling up of the channel between the piers. The slab pier burnt down to the water's edge in some places, which renders a breach all the more likely.

As to the further extension of the piers into the lake, I would respectfully suggest that before making any extension the effect of the present season's work be observed.

The bars move out as fast as the piers are extended.

Muskegon is in the collection district of Michigan, and the nearest port of entry is Grand Haven, twelve miles south.

It has a small light-house, with lights of sixth order.

Statement of vessels entered and cleared Muskegon Harbor, in the district of Michigan, during the year 1868, showing the number, tonnage, crews, and cargoes.

Articles.	Entered.	Articles.	Cleared.
Number of vessels	2,035	Number of vessels	2,441
Number of tons	396,498	Number of tons	388,851
Number of crews	35,390	Number of crews	18,477
Bushels corn	8,383	M lumber	253,213
Bushels oats	59,499	M laths	9,503
Tons hay	902	M shingles	7,740
Tons feed	14,070	M pickets	2,226
Barrels flour	133	Railroad ties	18,505
Packages merchandise	44,971	Cords slabs	3,778
		Cords bark	129
		Packages merchandise	3,993

B 7.

GRAND HAVEN HARBOR, MICHIGAN.

The pier on south side of channel was extended 100 feet, and the old pile-work built by the Detroit and Milwaukee Railroad Company, forming a part of the same pier interior to portion repaired, for a distance of 465 feet, as shown in blue on accompanying sketch.

* * * * * * * * *

The work during the present season is being done by Messrs. Squire & White, they being the only bidders, at the following prices:

Abstract of contract for improving harbor of Grand Haven, Michigan—Messrs. Squire & White.

Timber.—Pine, per cubic foot	$0 16
Piles.—Pine, per lineal foot	07
Oak, per lineal foot	15
Slab filling, per cord	2 25
Stone, per cord, 128 cubic feet	15 00
Iron.—Screw bolts, per pound	12
Drift bolts, per pound	06
Spikes, per pound	10
Putting in stone from pier, per cord	3 00
Driving and redriving piles, per lineal foot	07
Framing, per lineal foot	15
Tearing away old work pier, per running foot	1 75

To complete the improvement of this harbor there is necessary—

1st. A pier on the north side of the entrance to the river; and,

2d. A further repairing of old pile pier, built by the railroad company on south side of channel, for a distance of 600 feet, from repairs made this season inward.

The necessity for a north pier has been fully set forth in previous reports of Brevet Colonel J. B. Wheeler, and the same necessity still exists. This pier will be 1,700 feet long, and will cost $200,000.

The repairing of the old south pier will cost $14,000.

This harbor is the most important of all those on the east shore of Lake Michigan, and is by far the best; and when once the proposed improvements are completed, it will be a long time before any money need be spent on it.

Grand Haven is the port of entry for the district of Michigan, which includes all harbors from Aux Becs Scies south to St. Joseph. It is an important point, being one terminus of the Detroit and Milwaukee railroad, and on an extensive line of communication between the East and West. It is also a lumber market of some importance. It has a light-house.

Statement of vessels entered and cleared Grand Haven Harbor, in the district of Michigan, during the year 1868, *showing the number, tonnage, crews, and cargoes.*

Articles.	Entered.	Articles.	Cleared.
Number of vessels	2, 714	Number of vessels	2, 591
Number of tons	528, 278	Number of tons	511, 310
Number of crews	22, 054	Number of crews	20, 904
Bushels corn	73, 037	M lumber	186, 394
Bushels oats	76, 930	M laths	9, 503
Bushels wheat	7, 240	M shingles	7, 704
Tons hay	2, 202	M pickets	559
Tons feed	11, 562	M staves	2, 960
Barrels flour	105, 848	Railroad ties	55, 970
Barrels salt	6, 030	Cords wood	9, 546
Barrels pork and beef	5, 122	Cords bark	1, 488
Bushels potatoes	4, 916	Cords slabs	523
Sacks wool	2, 356	Bushels fruit	1, 841
Cords stone	852	Barrels flour	3, 500
M brick	17	Pounds leather	116, 630
Tons coal	860	Barrels plaster	116, 630
Packages merchandise	104, 180	Tons charter rock	41, 720
		Packages merchandise	145, 899

B 8.

BLACK LAKE HARBOR.

During the past fiscal year five cribs (32 feet by 20 feet) have been placed on line of south pier, extending it 160 feet, and one crib (32 feet by 20 feet) on north pier, and the superstructure finished.

* * * * * * * * *

During the winter the south pier settled very irregularly, and the outer crib was moved from its place.

By virtue of paragraph 2, Special Orders No. 38, dated Headquarters Corps of Engineers, Washington, D. C., May 7, 1869, a board of engineers assembled May 13, 1869, for consideration of certain structures for harbor improvements on Lake Michigan.

In accordance with the opinion of the board, which was approved by the Chief of Engineers United States Army, the following work to improve this harbor will be done the present year:

An enrockment will be placed along the side of the south pier to prevent a further scouring out of the sand; the south pier will be repaired; a crib superstructure will be built to prevent a breach between the crib-work and the shore, where the channel on both sides is now protected by a brush pier;

And a pile revetment will be built at the head of the cut, to prevent the stream washing out the sand and depositing it on the outer bar.

In addition, the point at the head of the cut should be dredged away in order to straighten the channel, which, together with the necessary revetment, will require an additional appropriation of $10,000.

Black Lake is in the district of Michigan, twenty-two miles south of Grand Haven, the nearest port of entry.

The nearest light-house is at the mouth of the Kalamazoo River, eight miles distant. It is a fixed light of the sixth order. Holland is at the head of the lake, six miles from the mouth, and is the nearest settlement.

No.	Names of bidders, and residence.	I. For furnishing piles, white oak, 24 feet long, 12 inches thick at all points.	I. For furnishing 8 × 12 inches oak timber.	I. For furnishing 4 × 8 inches oak timber.	I. Total.	II. For furnishing 32-inch drift bolts.	II. For furnishing 20-inch drift bolts.	II. For furnishing screw-bolts, 24 inches long.	II. Washers for screw-bolts.	II. Total.	III. For driving piles.	III. For framing timber.	III. For furnishing and putting in place stone.	III. For furnishing cords of brush or slabs.	III. Total.
		Per running ft. of pile.	Per running ft.	Per running ft.		Per lb.	Per lb.	Per lb.	Per lb.		Per foot driven.	Per lineal ft. of timber used.	Per cord of 128 cub. ft.	Per cord of 128 cub. ft.	
1	F. S. White, Grand Haven	$0 13½	$0 24	$0 12	$3,891 15	$0 4¼	$0 4¼	$0 6¼	$0 10	$860 22	$0 20	$0 14¼	$12 94	$3 70	$11,506 90
2	John Roost, Holland	13½	24	12	3,891 15						19	14½	13 90	4 00	12,095 00
3	Manson Dodge, Volney, N. Y.	26	20	10	7,061 40	5	5	5½	5½	893 22	30	11½	16 25	5 00	14,616 10
4	Kimball & Kaulert, Holland	16½	18	9	4,568 85	4½	4½	8½	8½	926 12	27½	10	12 40	3 75	11,597 25
5	J. N. Sanders, Milwaukee	17	24	19	4,874 30								13 97	9 65	

The contract was accordingly awarded to F. Stewart White, he being the lowest bidder on all the items.

Statement of vessels entered and cleared Black Lake Harbor, in the district of Michigan, during the year 1868, *showing the number, tonnage, crews, and cargoes.*

Articles.	Entered.	Articles.	Cleared.
Number of vessels	441	Number of vessels	424
Number of tons	19,971	Number of tons	15,433
Number of crews	1,765	Number of crews	1,725
Bushels corn	2,710	M lumber	3,647
Bushels oats	4,487	M shingles	31,392
Bushels wheat	2,741	M staves	2,793
Tons hay	233	Railroad ties	42,378
Tons feed	519	Cords wood	9,409
Barrels flour	64	Cords bark	4,625
Barrels salt	1,710	Boxes fish	169
Bushels potatoes	410	Packages merchandise	629
Hides	550		
Tons coal	31		
Packages merchandise	10,714		

B 9.

MOUTH OF KALAMAZOO RIVER, (SAUGATUCK.)

No work was done at this harbor, as it was not until an accurate survey could be made that proper plans and estimates could be made. They were laid before a board of engineers, convened by virtue of paragraph 2, Special Orders No. 70, dated Headquarters Corps of Engineers, Washington, D. C., July 16, 1869.

The board of engineers approved the plans and estimates, and, under the further approval of the Chief of Engineers, steps were taken at once to commence the work.

The work proposed for the present season's work is to revet the left bank of the river, as shown on the accompanying sketch, from A to B. It is hoped that this will be completed by the 1st of November.

The improvements, shown in rèd, on the north side of the entrance to the river, should be made to complete the improvement of the mouth of the river.

The present piers at the mouth of the river were built by the local authorities, and in building them they contracted the stream so much that at high water in the river the piers are much endangered.

To obviate the danger it is proposed to build a north pier and interior revetment, as shown on the accompanying sketch, and remove the present slab revetment.

These improvements will cost $75,000, which amount can be profitably spent during the fiscal year ending June 30, 1871.

Saugatuck is in the collection district of Grand Haven. It is not a port of entry. There is a light-house of the sixth order on the north bank of the river, situated on a rise of 18 feet.

Statement of vessels entered and cleared Saugatuck Harbor, in the district of Michigan, during the year 1868, *showing the number, tonnage, crews, and cargoes.*

Articles.	Entered.	Articles.	Clearede.
Number of vessels	131	Number of vessels	315
Number of tons	37,545	Number of tons	19,726
Number of crews	2,161	Number of crews	2,287
Tons of hay	70	M lumber	18,911
Tons of feed	3,310	M laths	933
Barrels flour	220	M shingles	14,395
Barrels pork and beef	700	M pickets	110
Hides	1,350	Railroad ties	2,000
Packages merchandise	8,068	Cords wood	9,884
		Pounds leather	63,100
		Packages merchandise	811

B 10.

SOUTH HAVEN HARBOR.

During the fiscal year eight cribs (32 feet by 20 feet) were placed on the prolongation of the north pier, and the superstructure built thereon.

During a heavy northwest blow last spring the outer crib of the north pier was carried away, and this was replaced and ballasted with stone.

Amount on hand July 1, 1868	$13,315 11
Amount expended during fiscal year ending June 30, 1869	11,147 55
The balance on hand and in the United States treasury, subject to expenditure for the improvement of this harbor, was, July 1, 1869	2,167 56

Which amount will be entirely exhausted in payment of work in replacing the displaced crib.

Amount required for fiscal year ending June 30, 1871, $72,000.

To complete the proposed improvement at this harbor the piers should be extended each 400 feet, which would cost $52,000. The old slab pier should be removed, as shown on the accompanying sketch, in order to widen the entrance to the river, and the channel should be dredged to a depth of 12 feet. The latter two items would cost $30,000.

The bottom of the channel is of blue clay, and will require but little dredging after a good channel shall have once been made. A railroad is now being constructed between this place and Kalamazoo, Michigan, which will bring considerable shipping to this point.

South Haven is situated about sixty miles south of Grand Haven. It is important as a harbor of refuge, and as an outlet to the lumber district of the counties of Allegan and Van Buren.

Statement of vessels entered and cleared at South Haven, in the district of Michigan, during the year 1868, showing the number, tonnage, crews, and cargoes.

Articles.	Entered.	Articles.	Cleared.
Number of vessels	420	Number of vessels	417
Number of tons	25,882	Number of tons	25,158
Number of crews	1,950	Number of crews	1,936
Bushels oats	20	M lumber	11,931
Tons hay	400	M laths	130
Tons feed	1,379	M shingles	161
Barrels flour	1,057	Railroad ties	13,904
Barrels salt	290	Cords wood	9,556
Cords of stone	556	Cords bark	3,960
M brick	1,000	Bushels fruit	4,676
Barrels lime	486	Packages merchandise	44
Packages merchandise	7,048		

B 11.

ST. JOSEPH HARBOR.

No work has been done during the past fiscal year. The money expended was for work already done.

* * * * * *

To permanently improve this harbor the south pier should be extended in a direction north 78° west from the present west end for a distance of 928 feet, at a cost of $58,000. And a north pier should be

built parallel to it for a length of 940 feet, at a cost of $58,666. The present direction of the piers is wrong, as is fully shown by experience. The natural direction of the current of the river, after leaving the end of the present south pier, under the various forces acting on it, is in the direction I would propose for any new improvements of this harbor. I am fully sustained in my views by Colonel Wheeler, my predecessor, in charge of the improvement of this harbor.

The light-house is on the keeper's wooden dwelling.

Statement of vessels entered and cleared St. Joseph Harbor, in the district of Michigan, during the year 1868, *showing the number, tonnage, crews, and cargoes.*

Articles.	Entered.	Articles.	Cleared.
Number of vessels	664	Number of vessels	671
Number of tons	53,131	Number of tons	105,939
Number of crews	3,939	Number of crews	6,857
Bushels oats	297	M lumber	9,390
Bushels wheat	120	M shingles	15
Barrels flour	1,069	Railroad ties	119,826
Barrels salt	1,529	Cords wood	3,716
Barrels pork and beef	733	Bushels fruit	498,011
Hides	13,555	Bushels potatoes	12,450
Cords of stone	303	Barrels flour	6,561
Tons coal	24	Packages merchandise	32,072
Packages merchandise	2,304		

B 12.

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wisconsin, May 1, 1869.

GENERAL: I have the honor to inclose herewith a sketch of Black Lake Harbor improvements, showing work already done and proposed repairs.

I would respectfully request authority to advertise and contract for and make the following repairs:

1. Repairing portion of old north brush pier (marked A on sketch) for a distance of 150 feet, from repairs made last year, inward. This is rendered necessary to prevent a breach between the repaired pier and shore line. This can be done at a cost of about $1,000.

2. Repairing similar portion of old south brush pier (marked B) for the same reason, at a cost of about $1,000.

In making these repairs I propose to drive two rows of close piling, put on capping pieces, and build three feet of superstructure of ordinary timber work, and ballast with sand.

3. Building 500 feet of pier, (marked C,) to prevent the current from eating into the sand hill and carrying out the sand to form a sand bar between the piers, and also from getting behind and destroying the old north brush pier. I would propose to construct this by driving a row of close piles on channel side of pier, and on the shore side a row of piles eight feet apart, capping these rows and tying them together by timber ties every eight feet in length of pier. This would cost about $3,600.

4. That part of the south pier built last year is in a very bad condition owing to the very irregular settling of the cribs that form its foundation. Besides a very great irregularity along the axis of the pier, the whole pier inclines to the southward, in some places so badly that the top surface, formerly level, now dips to the south at an angle of 25°. The outer crib has moved from its place, and the ice and force of storms have destroyed it for three courses below the water surface.

The cribs of this pier are founded on brush sink pieces similar to those used in building the dykes of Holland. However useful they may have been found there, they have been entirely useless in this case.

To repair this and prevent any washing out from under the south edge of this pier, I would propose an enrockment, and to preserve this enrockment I would drive a close row of piles along the entire length of the pier and tie it to the crib work. The cost of this would be $5,000.

If the work proposed meets your approval, I would respectfully request that the authority asked be sent me at once, so that the work may be commenced by the 1st of June.

The amount of the appropriation for improving this harbor remaining unexpended is $24,488 59. The amount required for the proposed repairs is $10,600.

Very respectfully, your obedient servant,

F. U. FARQUHAR,
Captain U. S. Engineers and Brevet Lieut. Col. U. S. Army.

Brevet Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. Army, Washington, D. C.

B 13.

Proceedings of a board of engineers convened at Milwaukee, Wisconsin, in obedience to the following order:

[Special Orders No. 70.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., July 16, 1869.

* * * * * * * * *

2. A board of engineers, to consist of Lieutenant Colonel I. C. Woodruff, brevet brigadier general United States Army; Major J. B. Wheeler, brevet colonel United States Army; Captain F. U. Farquhar, brevet lieutenant colonel United States Army, will convene at Milwaukee, Wisconsin, on the 23d instant, or as soon thereafter as practicable, for the consideration of the project for the improvement of Saugatuck Harbor, Michigan.

* * * * * * * * *

By command of Brigadier General Humphreys.

THOMAS LINCOLN CASEY,
Major of Engineers and Brevet Colonel United States Army.

MILWAUKEE, WISCONSIN, *July* 23, 1869.

The board met in pursuance of the above order.

Present: Lieutenant Colonel I. C. Woodruff, brevet brigadier general United States Army; Major J. B. Wheeler, brevet colonel United States Army; Captain F. U. Farquhar, brevet lieutenant colonel United States Army.

The board then proceeded to the consideration of the project for the improvement of Saugatuck Harbor, as given to the Chief of Engineers by Brevet Lieutenant Colonel F. U. Farquhar, captain United States engineers, in his letter dated "Milwaukee, Wisconsin, July 5, 1869," as follows:

UNITED STATES ENGINEER OFFICE,
Milwaukee, Wisconsin, July 5, 1869.

GENERAL: I have the honor to inclose a tracing showing the mouth of Kalamazoo River and the proposed improvements.

In the spring of 1868 occurred a freshet which carried away a large

portion of the east end of the south pier. Since then those interested have lengthened the north pier to the westward, and built a wing to protect the present east end of the south pier.

The width between the piers is only 200 feet. This width is too small by at least 100 feet. This becomes manifest by referring to the width of the river at the furthest point inland, shown on the inclosed tracing.

The Kalamazoo River is navigable for small steamers for nearly sixty miles from its mouth, and at all times discharges a considerable amount of water.

The point, however, that requires immediate work is the left bank of the river, at the bend above the mouth. A large shifting bank of sand on the right bank of the river just above this bend has been for years steadily moving southward, forcing the mouth of the stream in the same direction. By revetting the left bank at the bend, as shown in red from A to B on the tracing, this southerly progress of the river-bed can be arrested. This will require about 975 feet of revetting.

The river, after leaving the point B, widens out, and in consequence is much shallower. By continuing the pile revetment from B to the east end of the south pier the stream will be confined, and very soon a good deep channel will result. This will require 1,725 feet of pier. This pile revetting is built on the plan approved by the board of engineers for revetting inside work at Black Lake Harbor. I inclose a tracing showing the work.

The following is the estimate for the above 2,700 feet of work:

214,800 feet board measure, pine timber, at $10 per M	$2,148 00
7,200 feet board measure, oak timber, at $30 per M	216 00
2,498 piles, at $3	7,494 00
2,538 cords of brush, at $1 50	3,807 00
378 cords of stone, at $11	4,158 00
26,174 pounds of drift bolts, at 4 cents	1,046 96
9,281 pounds of screw bolts and washers, at 5½ cents	510 46
Driving 2,498 piles, at $2	4,996 00
Framing 20,932 lineal feet of timber, at 13 cents	2,721 16
	27,097 58
Amount of allotment	30,000 00
	2,902 42
Deduct amount authorized for price of dredge	2,000 00
	902 42

The improvements on the north side of the mouth of the river will be much more expensive, and if done will have to be paid for from some future appropriations. The following is an estimate of the cost of constructing this work:

1,660 feet of revetment on north side of river to lake-shore line	$16,045 18
770 feet of close piling, from shore line to inner end of proposed crib-work	20,032 44
6 cribs, 32 by 20 by 17 feet on outer end of pier	8,038 36
60,740 cubic yards of dredging, at 25 cents	15,185 00
Total	59,300 98

* * * * * * * * *

All I propose to do this season is to improve by revetting the left bank, as before described, leaving the north side improvements for some future period.

Hoping this may meet with your approval, I have the honor to be, very respectfully, your obedient servant,

F. U. FARQUHAR,
Captain U. S. Engineers and Brevet Lieut. Col. U. S. Army.

Brevet Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. Army, Washington, D. C.

The board having carefully examined the maps of surveys of this harbor made during the years of 1867, 1868, and 1869, find that the right bank of the river, at the bend near the entrance, has encroached upon the channel, and that the left bank has been worn away. This action is still going on, and threatens to entirely change the entrance to the harbor and materially affect the present improvements, unless stopped. They also find that the system of improvement devised and built by the local authorities of Saugatuck contracts too much the width of the water-way, and, in consequence, a large amount of the piering has been carried away by the water during freshets.

The board are therefore of the opinion that the left bank of the river, from A to B, as shown on the attached sketch, should be defended from the abrasion of the current which impinges against it, and that the current should be forced to flow out on the north side of the present south pier.

They therefore approve and recommend the plan proposed by Brevet Lieutenant Colonel F. U. Farquhar, captain United States engineers, as the best that can be done with the amount of money in his hands allotted to this harbor to effect these purposes and preserve the entrance to the harbor.

All of which is respectfully submitted.

I. C. WOODRUFF,
Lieut. Col. and Brevet Brigadier General U. S. Army.
J. B. WHEELER,
Major and Brevet Colonel U. S. Army.
F. U. FARQUHAR,
Captain and Brevet Lieutenant Colonel U. S. Army.

There being no other business before it, the board adjourned *sine die.*

I. C. WOODRUFF,
Lieut. Col. and Brevet Brigadier General U. S. Army.
F. U. FARQUHAR,
Captain and Brevet Lieut. Col. U. S. Army, Recorder.

B 14.

MILWAUKEE, *April* 28, 1869.

GENERAL: I have the honor to inclose herewith a drawing, on which are shown a plan elevation and sections of a portion of a pile pier.

Should an allotment be made for the purpose, there will be built four new piers at the harbors under my charge, viz: a north pier at Aux Becs Scies, a north pier at Pentwater, and two piers (north and south) at the mouth of White River.

Should it meet with your approval, I would like to build these piers from the shore line to the 9-feet curve in accordance with the inclosed plan.

At White River the clay is found from 2 to 6 feet below the bottom of the water.

At Pentwater a bridge pier, built on piles, has stood well for many years; while the south pier, built last season, and which is founded on cribs, has settled so irregularly as in some places to break the superstructure.

At Aux Becs Scies, clay is reported at 10 feet below the bottom.

The best works on the east shore of Lake Michigan, as far as piers are concerned, are founded on piles.

In all cases I would propose a pier-head, founded on a crib, very carefully constructed, and properly placed in position.

Taking the lowest prices on which to base an estimate, a crib, properly bedded at 12 feet below the surface of the water, 32 by 20 feet in plan, and with a superstructure 5 feet in height, will cost *not less* than $1,565.

The same length of pier built in accordance with the inclosed plans will cost not more than $973.

Neither of these estimates includes the cost of superintendence.

The manner of building the pier is as follows: Two rows of close piling are driven 13 feet apart, and at intervals of 32 feet in length of pier; these two rows are connected by a cross row of close piling.

On the outer faces of the side rows of piles a horizontal shoulder of *not more* than 6 inches deep is cut, above which the faces of the piles are hewn off to make flat surfaces for the water-sill to rest against, the inner faces of the piles being scored, so as to make a fair bearing for the binder.

The water sill (8 inches by 12 inches) is then put in place with the binder on opposite face of piles, and screw-bolts 1⅛ inch in diameter hold together the water sill, piles, and binder.

The two rows of close piling are held together by ties (12 inches square) placed at intervals of 8 feet.

On this foundation the ordinary superstructure is built, excepting that at intervals of 32 feet in length of pier a solid wall of ties is built, these ties being bolted to the cross rows of close piling. A ballasting of stone is used. Many of the details I have taken from work done by General Cram and Colonel Wheeler.

I have the honor to be, very respectfully, your obedient servant,

F. U. FARQUHAR,
Captain U. S. Engineers and Brevet Lieut. Colonel U. S. Army.

Brevet Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army, Washington, D. C.

Proceedings of a board of engineers convened at Milwaukee, Wisconsin, in obedience to the following order:

[Special Orders No. 38.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., May 7, 1869.

* * * * * * * * * * *

2. For the consideration of certain structures for harbor improvement upon Lake Michigan, a board of engineers, consisting of Lieutenant Colonel W. F. Raynolds, brevet brigadier general United States Army, Major J. B. Wheeler, brevet colonel United States Army, Major W. McFarland, brevet major United States Army, Captain F. U. Farquhar, brevet lieutenant colonel United States Army, will assemble at Milwaukee, Wisconsin, on the 13th instant, or as soon thereafter as practicable. The junior member will act as recorder.

By command of Brigadier General Humphreys.

THOMAS LINCOLN CASEY,
Major of Engineers and Brevet Colonel United States Army.

THURSDAY, *May* 13, 1869—1 *o'clock p. m.*

The board having met in pursuance of the above order—present, Lieutenant Colonel W. F. Raynolds, brevet brigadier general United States Army, Major J. B. Wheeler, brevet colonel United States Army, Captain F. U. Farquhar, brevet lieutenant colonel United States Army; absent, Major W. McFarland, brevet major United States Army—the board was organized by the reading by the senior member, Lieutenant Colonel W. F. Raynolds, brevet brigadier general United States Army, president of the board *ex officio*, of the order of assembly given above, and at once proceeded to business. The following letter of instructions, from the Chief of Engineers, was laid before the board, and read to it:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., May 7, 1869.

GENERAL: The board of engineers convened in pursuance of Special Order No. 38, Office of the Chief of Engineers, May 7, 1869, for the consideration of projects for harbor improvements, will take into consideration the plan of a "pile pier" proposed by Brevet Lieutenant Colonel F. U. Farquhar, for the improvement of the harbors on the eastern coast of Lake Michigan, and also his plans for the repairs and improvement of the harbor of Black Lake on that coast, and will report fully in regard to the same, suggesting such alterations or amendments, if any, as may seem to it to be advantageous and proper, having especially in view the character of the bottom at the various harbors, their situation, and the forces and direction of the currents affecting them, whether caused by storms or otherwise.

Brevet Lieutenant Colonel Farquhar will furnish the board from the records of his office with such drawings, maps, and other information as may be required for its investigations. He will be instructed to pay the expenses incurred by the board of engineers, including the mileage of the members to Milwaukee and returning to their stations, from the appropriation for examinations and surveys on the northwest lakes.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

Brevet Brig. Gen. W. F. RAYNOLDS,
Lieut. Col. of Eng's, President Board of Eng's, &c., Detroit, Mich.

The original "plan of a pile pier proposed by Brevet Lieutenant Colonel F. U. Farquhar for the improvement of harbors on the eastern

coast of Lake Michigan, and his plans for the repairs and improvement of the harbor of Black Lake on that coast," were then laid before the board and partly discussed; after which the board adjourned to meet at 9 o'clock a. m. on the succeeding day, at the same place, United States Engineer's office, Milwaukee, Wisconsin.

FRIDAY, *May* 14, 1869.

The board met pursuant to adjournment, and proceeded to the completion of the business before it. Present all the members.

After due deliberation the board submit the following opinions and recommendations in regard to the repairs and improvements of Black Lake Harbor:

OPINIONS, ETC.

1st. The board are of the opinion that the repairs and improvements recommended by Brevet Lieutenant Colonel Farquhar are necessary.

That they approve of items I and II of the repairs recommended by him, which are as follows:

"I. Repairing portion of old north brush pier (marked A on sketch) for a distance of 150 feet from repairs made last year, inward. This is rendered necessary to prevent a breach between the repaired pier and shore line."

"II. Repairing similar portion of old south brush pier (marked B) for the same reason."

"In making these repairs I propose to drive two rows of close piling, put on capping pieces, and build three feet of superstructure of ordinary timber work, and ballast with stone."

(The use of the word "sand" instead of "stone," in Colonel Farquhar's recommendation, was a clerical error.)

The board also approve item III, which is as follows:

"III. Building five hundred feet of pier (marked C) to prevent the current from eating into the sand hill and carrying out the sand to form a sand-bar between the piers, and also from getting behind and destroying the old north brush pier. I would propose to construct this by driving a row of close piles on the channel side of pier, and on the shore side a row of piles eight feet apart, capping these rows, and tying them together by timber ties every eight feet in length of pier.

In addition, the board would recommend that the pier be filled with brush to the water's edge, with sufficient stone to ballast it.

The board make the following recommendation in regard to item IV, which states: "That part of the south pier built last year is in a very bad condition, owing to the very irregular settling of the cribs which form its foundation." To repair this, and prevent any washing out from under the south edge of this pier, the board think the amount of stone proposed by Brevet Lieutenant Colonel Farquhar, used simply as an enrockment along the south side of the pier, will be sufficient without the protecting row of piles.

2d. The board has examined carefully the plan of a pile pier proposed by Colonel Farquhar, and coincides that this structure may be used at the point suggested, and subject to the conditions given by him. They approve of his dividing the pier into compartments, and think it is a source of strength to the structure.

In approving this plan, the board wish to state that they do not propose to supersede the crib pier, excepting in the case where the cost is

an essential element, and where the pier will not be liable to shocks or blows from passing vessels or floating bodies.

As the efficiency of the pile pier will depend upon the proper driving of the piles, and other details of construction, the board would recommend that the work be done by hired labor and not by contract.

All of which is respectfully submitted.

W. F. RAYNOLDS,
Lieutenant Colonel, Brevet Brigadier General.
J. B. WHEELER,
Major of Engineers and Brevet Colonel.
WILLIAM McFARLAND,
Major of Engineers.
F. U. FARQUHAR,
Captain U. S. A. and Brevet Lieutenant Colonel, Recorder.

There being no business before it, the board adjourned *sine die.*

W. F. RAYNOLDS,
Lieutenant Colonel of Engineers and Brevet Brigadier General.
F. U. FARQUHAR,
Captain of Engineers and Bvt. Lieut. Col. U. S. A., Recorder.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., May 26, 1869.

COLONEL: The proceedings and recommendations of the board of engineers convened at Milwaukee by Special Orders No. 38, Headquarters Corps of Engineers, May 7, 1869, of which you were a member, are approved.

You will govern yourself accordingly.

By command of Brigadier General Humphreys.

Very respectfully, your obedient servant,

JNO. G. PARKE,
Major of Engineers, Brevet Major General U. S. A.

Capt. and Bvt. Lieut. Col. F. U. FARQUHAR,
Corps of Engineers, Milwaukee, Wisconsin.

APPENDIX C.

Brevet Major General Cram's report upon the rivers and harbors in his charge for the fiscal year ending June 30, 1869.

1. IMPROVEMENT OF ST. MARY'S RIVER, MICHIGAN.

During this fiscal year the work of improvement has been confined entirely to dredging in Lake George, middle channel, (see Sketch No. 1,) with a view of making it 200 feet wide at bottom throughout, and 14 feet deep in the middle and 13½ feet at the sides; and for this purpose the amount of clay and sand removed has been (from 1st of July, 1868, to 30th June, 1869) 76,342 cubic yards.

The amount expended and paid for this to the contractors, John Brown & Co., has been	$36,644 16
The amount paid and due for contingencies	1,408 94
Total expended on the work this fiscal year	38,053 10

The progress of the work has been such that at the end of this fiscal year the channel from its upper extremity A down to B, 5,050 feet, has been very nearly completed—leaving only some lumps and ridges, left by the dredge the first time going over, yet to be taken out; and the remainder of the channel, from B down to C, 2,170 feet, has been wrought generally to the full depth, but not as yet the full width intended.

It is estimated that the amount measured in the natural bed, and yet to be taken out to bring this part to the full width contemplated, is 17,175 cubic yards, requiring about one month for two dredges, which are now engaged, to accomplish the task.

The amount available out of the specific appropriations of 1866 and 1867, and out of the allotments from the general appropriations of 1864 and 1869, on the 1st July, 1869, is $14,799 47.

With this sum it is intended to complete, if possible, this important channel during the remainder of the season of 1869, and on its completion the present contract with John Brown & Co. will be closed. The sum allotted out of the last appropriation will not, I fear, be sufficient to make B C to the full width.

Other places in this river requiring improvement.

These have been surveyed, and the plans and estimates made and reported during this fiscal year. (See my report accompanying my letter to headquarters corps of engineers, 20th January, 1862; also my more specific report upon these places of date 30th June, 1869, accompanying this annual report.)

From these special surveys it is estimated that the improvements of the places other than the Lake George Channel and the Saut Ste. Marie Canal will cost as follows:

East Neebish, west channel	$59,071 00
Channel at head of Rain's Island	56,380 00
Channel at foot of Sugar Island	19,570 00
Removing boulder rocks above the canal	3,000 00
Removing boulders in places below the canal	3,000 00
Total	141,021 00

The present commerce passing through this river justly demands these improvements.

Sault de Ste. Marie Ship Canal.

Sketch No. 2. This, it is well known, was built by the State of Michigan from the proceeds of public lands donated by the United States government for the purpose. Since it was built the commerce of Lake Superior has augmented so very much as now to require the capacity of the canal to be proportionably increased. With the view of its being improved by the United States government, the legislature of Michigan, in its last session, resolved by unanimous vote to cede this important work to the United States; and thus it is obvious the first step has been taken in the right direction for its improvement.

This work cannot be made to answer the present and fast-growing demands of the Lake Superior commerce short of the following items of improvement:

1. Deepen the existing lakes to a depth of 16 feet on the miter sill. There is now, in the low stage of navigation, only 10⅝ feet.

2. Deepen the canal to 17 feet, and render its sloping, rough, rocky sides vertical, and safe for vessels to pass through.

3. Construct a prolongation of the upper end of the north canal bank, to enable vessels coming down under a strong west wind to more safely enter the canal than they can at present.

4. Construct another lock, overcoming the fall with one lift, alongside the present two locks.

The expense of these improvements cannot be given until an examination and survey, which I respectfully recommend, shall be ordered by the proper authority and made for the purpose.

The cost of the necessary examination and survey, of the drawing of the plans and the making of the estimates, could be legally defrayed out of existing appropriations, and would be about $1,200. But this much in respect to these improvements I am prepared to say, viz: that all can be done without injury to the present lock walls, and without any destruction of existing works, except the old gates and miter sills, and some of the old grillage works. And that every item can be economically accomplished, without interfering at all with the passage of vessels, by having everything and all materials ready in the summer, and taking advantage of the time to do the work between the closing and opening of the seasons of navigation.

The total amount required yet to be appropriated to complete the improvements contemplated in this river, besides for this canal, it has been stated is $141,021.

The amount required to be appropriated to economically carry on these improvements for the fiscal year ending June 30, 1870, is $60,000.

The amount for dredging, to keep all the improvements, when made, perpetually in good condition, including the Lake George channel, I think may be safely set down not to exceed annually $10,000.

2. IMPROVING MOUTH OF AU SABLE RIVER, MICHIGAN.

This river is long, rapid, and, as its name imports, is full of sand, which, being washed down from all the way for one hundred and twenty miles up, forms an everlasting deposit at its mouth.

It debouches at the north part of the base of Saginaw Bay, of Lake Huron, at a point about the middle of its west coast, and, with the exception of the mouth of the Saginaw River, is the only point on Lake Huron where the United States government has expended money for improving the harbors or rivers.

It is only the very great value of the pine district bordering upon the Au Sable and its branches that justifies an improvement at its mouth, merely to enable vessels to enter and depart with their cargoes of lumber, without the necessity of lighterage over the bar, and to afford them some shelter while loading. The fishing interest is also benefited by the improvement.

For these purposes ten feet depth was adopted for the water-way between the piers, and this, if it can be attained and maintained, will be ample. It was in this depth that all the cribs of the lines of piering shown on Sketch No. 3 have been posed on a sand and gravel bottom, attained by dredging—the cribs having bottoms with spaces for the stones; as many as would fall through to rest on the ground under the cribs; and the cribs were stayed each by four piles driven in the interior corners, to a depth of nine to twelve feet into the ground beneath. The

pockets at the horns of the cribs are filled with a layer of brush in bundles, then with a layer of stones, then slabs, then with stones to the water surface; the other pockets of the cribs are entirely filled with stones. The cribs were constructed with horns, and touched each other end to end by the extremities of their horns.

During the fiscal year just closed, and down to the close of last season's work, thirty such cribs had been sunk in place, and were then left to their fate during the past winter, without any superstructure above water. The line of the crib-work on the north side was 240 feet, and on the south side 660 feet, in extent.

By a glance at the map of Lake Huron it will be seen that the mouth of the Au Sable is exposed to an azimuth of the whole broad expanse of the lake, from due southeast around by east to due north, and subject to the full fury, without any cover from islands, of winds from all directions in this azimuth; and the *effect* of the waves upon the cribs depending for the measure of its power upon the extent of the water expanse, the force *per se* of the wind, and duration of the gale, we shall see that our work at Au Sable was to be put to the very severest test after quitting it, 25th of last November.

Not only during the fall, winter, and spring was it subjected to the momentum of all the storm-waves, but in February, for a three days' continuous northeast by east gale, when the ice had broken up and was in motion, the work was subjected to a battering ram of icebergs oscillating in the lake during the whole gale.

The outer crib's horns of the south line affording a fair opportunity for the ice to act upon, were broken, and about half of the timbers of the crib were forced off, and two of the piles were broken short off, and several cords of filling washed away; but the lower part of the crib remained firm. The work, being only up to the water surface, was attacked at every point. The stay-piles performed the office they were intended for, else many of the thirty cribs must have been knocked out of their beds. Other than what has now been stated, no damage of consequence was done to our work.

During the winter, as was expected, the ice settled down and formed a complete *dam* on the summit of the bar between the piers, the water there being only two and a half to three feet deep. The water, in its pent-up effort to find its way out, washed a channel out in the bottom, where most yielding, along on the face of the south pier, to a depth of fourteen feet for an extent of 150 feet, under and past the ice-dam; this depth being four feet lower than the bottoms of cribs, two of the cribs near the angle careened inward somewhat, though not so much as to do much harm. The stay-piles of the five cribs along here well performed their office. I had a riprap of stones put along here, close up to the cribs, to prevent further scowering. Most of the work, marked A, that was put in by Mr. Loud, was washed away, and about sixty feet of the outer part of Mr. Backus's work, marked C. These works, as before reported, were put in by these mill proprietors at their own expense, on the lines of the location of our piers, *before* we commenced work. Mr. Backus has filled his gap with slabs; that part of sixty feet which was washed away was filled with "edgings," which proved too weak. Loud's gap was also filled with edgings; had he driven his piles well, and made it sixteen instead of five feet wide, and filled with slabs, with his brush, and weighted the filling down, his work would have stood.

On the whole, considering the severity of the tests our cribs have

been subjected to, I think we have reason to be thankful that so little damage has been done to them.

I now have to report the effect of the spring freshets upon the sand deposit between and exterior to the outer ends of the piering. To ascertain what changes had occurred, I directed the inspector, Mr. H. G. Rothwell, to make a survey of the harbor at the close of the freshets, which he did in the month of May last. The results of this survey with soundings are shown on Sketch No. 3, which shows that between the piers nowhere is there less than seven feet water, whereas, on quitting work last November, the shoal gave us only two and a half to three feet water; but then the ten-feet curve was only 215 feet beyond the extremity of the south piering, whereas now, by the last survey, the ten-feet curve is 525 feet beyond that same extremity, further out in the lake by 310 feet, proving that the deposit has been moved out into deeper lake water, at the same time giving vessels a much greater draught between the piers. I understand lumber vessels drawing seven and a half feet find no difficulty in departing or entering.

Believing that the settling of our cribs had ceased after this spring's flood, operations were recommenced for the season, in June, for repairing damages done by the ice, and leveling up the cribs to the water surface, and filling with stone to make up for vacancies by settling, and for what had been washed away during the gales. I have now brought the narrative of the work to the close of this fiscal year.

The amount expended during the fiscal year just closed is in items as follows:

For materials and labor to contractors	$27,944 51
Yet due for materials and labor	1,900 48
For contingencies	1,949 47
Total	31,794 46

This leaves, on the 1st July, 1869, available of the appropriation of 2d March, 1867, the sum of $13,707 92. With this the work is to be prosecuted from the 1st July, 1869, as follows:

1. To extend the north pier by two cribs, indicated in red, further into the lake.
2. To extend the south pier by three cribs further into the lake, and by two cribs further toward the shore in Loud's gap.
3. To lead up both lines of the cribs to surface of water, and put on the superstructure, with the filling and plank over all, should the money hold out.

The pier work will then be safe, and the force of the outflow will probably, without any dredging, keep the channel clear enough to allow vessels drawing seven to seven and a half feet to enter.

The sum required and yet to be appropriated to complete the improvement according to the original design is $20,000.

The amount required to carry on the work during the fiscal year closing June 30, 1870, is $33,707 92.

The annual expense of keeping this harbor open, after completing it, will be $3,000.

We are succeeding thus far in improving to a very satisfactory degree the mouth of this river. The business is so large there, that in all probability during this and the next fiscal year enough will be saved in lighterage to amount to all the expenditure yet made for this work.

3. IMPROVING MOUTH OF SAGINAW RIVER, MICHIGAN.

During this fiscal year the amount dredged of the hardest kind of material ever removed from under water without blasting was 24,699 cubic yards. (Sketch No. 4.) Besides removing from the new channel this hard material, one great boulder and several smaller ones, and one large old vessel hulk, and two immensely long and heavy oak timbers, were removed from it.

The work was completed on the 9th of October, 1868, to the full extent, width, and depth contracted for, viz: 6,800 feet in length, 195 feet in width at bottom, and 12 feet deep below the low stage during the calm weather of navigation. The fluctuations of the height of the water during gales, which often affect the whole Saginaw Bay, cannot be provided for, nor need they be. They sometimes for the time being vary the depth from one to three feet; but this condition only lasts a short time, when the water is found to have assumed its usual level.

By the middle of the last season's navigation, (in the summer of 1868,) vessels were availing themselves of the new channel, and it was entirely at their service by the 9th of October.

The amounts expended on the work during this fiscal year have been as follows:

Paid to the contractors	$35,503 45
Paid for contingencies	540 09
Total	36,043 54

And there is left in my hands of the allotment to this improvement out of the general appropriation of 1868, on the 1st July, 1869, the sum of $805 99.

Since the work was completed I have not heard of the slightest objection to, but much praise of, the navigation in this new channel. It is possible, however, that a small sand deposit may wash into it from the spit that was left between the old and new channels, seen at the southern end; further than this I have little or no apprehension of injury to the new channel.

I would recommend that the small sum of $805 99 above reported be kept to go towards defraying the expenses of removing a deposit should one be found at the southern extremity, also to help defray the proportional amount of office expenses occasionally chargeable to this work.

The total cost of this improvement has been, for work and all contingencies, $103,394 01. The improvement is of incalculable value to the commerce of the lakes, and one of which our government may justly be proud. The amount of lighterage which has been already saved since the new channel became available, to the end of this fiscal year, is at least double the whole cost of the work.

I estimate the annual expense at $1,500 for keeping this channel in good condition for all time to come.

4. IMPROVING ST. CLAIR FLATS, MICHIGAN.

The operations of this work have progressed with great rapidity considering its magnitude.

During the present fiscal year there have been delivered the following items of materials:

3,757 round white oak and rock elm piles.
2,047,376 feet, board measure, timber and lumber.

39,797 pounds nut, screw, and washer iron bolts.
128,013 pounds drift bolt iron, in bars.
17,400 pounds wrought eight and ten-inch spikes.

And the following items of work have been done, viz:

2,897 round piles prepared and driven for dike work.
8,445 sheet piles prepared and driven for dike work.
105,225 running feet of sawed timber framed and put into the dikes and fastened in place.
23,019 cubic feet of this timber creosoted.
253,287 cubic yards of earth dredged from the water-way between the dikes and put into the dikes and canal banks.

I have exhibited by different colors on the accompanying sketch No. 5 the different parts of the work, indicating the progress made from the beginning of the work to 30th June, the close of the present fiscal year.

The total length of the canal is to be about eight thousand two hundred feet. The width between the dikes, for water-way, three hundred feet. The depth of water, thirteen feet below the lowest stage known during navigation.*

The outer slope of the earthen banks to be protected where necessary from the action of the surf by a strong piling construction.

The full red lines show the extents of the dike revetments and banks as constructed to 30th June, 1869. These extents are 4,280 feet on the west, and 2,748 feet on the east side.

The dotted continuations of these red lines show the additional maximum extents, which are on the west side about three thousand nine hundred and twenty feet, and on the east about five thousand five hundred feet, yet to complete, if extended according to the original plan.

The blue tint, commencing at the head and extending down for 3,320 feet, also the blue tint, commencing at the lake end and extending up for 1,000 feet, show the total extent of 4,320 feet of the canal water-way which has been dredged out the full width and depth, and all the earth raised put into the canal banks.

The extent of the west protection to the outer slope of the west canal bank, to 30th June, is 1,748 feet running.

Since recommencing work (in April, 1869) this season, to the time of writing this report, (10th July, 1869,) the weather has been exceedingly unfavorable, indeed quite discouraging. Constant gales and rain have very much retarded the pile-driving, though little or no difficulty on these accounts would have been experienced in dredging; but the wood-work of the dikes must take the lead of the excavation and embankment. Owing, therefore, to the hinderance of the piling, the dredges have been half idle. If this state of the weather continues much longer, it will be impossible to complete the work by 1st of January next.

The contractor, John Brown, has had a heavy force on the ground, and diligently taken advantage of every moment of weather that would allow the work to go on. Five dredges, two steam crane derricks, six pile-drivers, and all the necessary attendant tugs and scows, with some two hundred men, have been on hand; and two more pile-drivers are being built, and if necessary two more dredges will be put in.

Another circumstance has operated to retard the work the present season more than I anticipated. I refer to act of Congress approved

*During all this season we have had more than fourteen feet in the finished part of the water-way. The revetments of the dikes next the canal water-way are fourteen feet thick, and these, with the outer portions of the canal banks, rise five feet above water.

July 25, 1868. Under the penalty of imprisonment and fine imposed in the third section of this act, and there not having been money enough appropriated to complete this work, I did not, during the past winter, order the contractor to furnish all the timber and other materials. The allotment out of the general appropriation of 1869 for this work being made 11th May, 1869, it was then too late in the season for millers to cut their logs to the proper length for so large an amount of timber. Hence on this account there may be some delay in the completion. Had we had, in early winter, funds appropriated sufficient to justify, all would have been ordered and engaged by the contractor in the winter, which is the proper time in all this part of the country for engaging bill timber or piles.

Notwithstanding, every reasonable effort is now being urged by me and promptly exerted by the contractor to complete the work as fast as possible.

Out of the appropriations specifically made for this work in 1866 and 1867, there was available at the beginning of the present fiscal year the sum of $214,427 24.

With funds from this the work has been prosecuted during this fiscal year to June 30, 1869, to the amounts expended as follows:

To contractors, for work and materials	$174,218 60
For creosoting timber	3,460 35
For contingencies	2,107 87
Total	179,786 82

The allotment to this from the general appropriation of 1868 was $86,000, and from that of 1869 the allotment was $144,000. Hence we perceive that we have, 1st July, 1869, funds from all sources available for the work to the amount of $264,640 42.

With this sum it is intended, during the remainder of the present season, to prosecute the work toward completion as far as the funds will reach in the accomplishment of the designs.

As yet I see no reasons justifying me in diminishing the estimate of funds. I asked, in my last annual report, to be appropriated, viz., $159,000. As only $144,000 was allotted, 11th May, 1869, out of the general appropriation, I am still short of that estimate by the sum of $15,000; and therefore the amount requested yet to be appropriated for this work, in addition to what we have available for the fiscal year ending June 30, 1870, is $15,000.

After completing the work, the annual amount for keeping it in good order and repair I estimate at $1,500.

5. EXAMINATIONS AND SURVEYS.

Under this head considerable field and office work has been done under my charge during this fiscal year.

1st. For a ship canal from the lower reach of the Maumee River, Ohio, directly through the Maumee Bay into deep water of the lake, (Erie,) a survey was made in the autumn of 1868, by Captain J. G. Lydecker, corps of engineers, then my assistant. The report, (dated 29th December, 1868,) with maps, plans, and estimates for this, was forwarded to headquarters corps of engineers about the close of 1868, or beginning of 1869.

2d. Minute surveys were also made during this fiscal year by Captain

H. C. Wharton, corps of engineers, my assistant, of several places in St. Mary's River, Michigan; also of the west channel of the East Neebish Rapids of the same river, by Lieutenants Greene and Haupt, corps of engineers, temporarily acting under my orders for this purpose; also of a part of this river at the head of Ram's Island, by a party kindly furnished by Brevet Brigadier General W. F. Raynolds, corps of engineers, superintendent of the lake survey, at my request.

The results of all these surveys are mapped and contained in a separate report of mine, dated 30th June, 1869, which will be sent with this annual report, and which will set forth the manner and expense of improving each place, to which attention is invited.

Before closing, I take occasion to recommend a survey and examination with a view to the improvement of the mouth of Sheboygan River, Michigan, as eminently worthy of being made by the government. The waters of this, and of its tributaries, occupying the northern part of the lower Michigan peninsula, emptying into the straits of Mackinaw, are of much importance, affording, as they do, an interior navigation by steam for some seventy to one hundred miles of lakes and connecting rivers, through extensive districts of excellent pine forests, and a great amount of farming soil of good quality. The obstruction at the mouth of the river can, with a moderate expenditure, be readily removed. And when removed, so as to do away with the present expensive lighterage, a result similar to that which has attended the opening of the new channel at the mouth of the Saginaw River would be immediately realized, and, in addition, there would accrue to the United States treasury, by the immediate sale of public lands consequent upon the improvement, ten-fold the amount of cost of deepening its mouth.

For these reasons, and the additional one that when the obstruction, which is not sand, but tough clay, is once removed there will be no filling up, I recommend the survey, which need not cost more than $750.

I have the honor to be, very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General U. S. Army.

Brevet Maj. Gen. A. A. HUMPHREYS,
Brigadier General, Chief of Engineers United States Army.

***Report, with maps, of the surveys and estimates of quantities to be removed by dredging, for the improvement of certain places in St. Mary's River, Michigan, made by authority from Chief of Engineers, September* 30, 1868, *rendered with my annual report, 30th June,* 1869.**

The several places requiring improvement, and for which these special surveys were made during the present fiscal year, in the autumn of 1868, are indicated on the engraved general map, and five of the places are shown on the accompanying maps of larger scale, as follows, in ascending the river:

1st. At the head of Ram's Island, thirty miles below Fort Brady, or the village of Sault de Ste. Marie.

Map A shows the position of the measured base and the soundings of the survey. The figure inclosed by the red dotted lines exhibits the place to be improved, by dredging out the small bowlders, and gravel and sand deposit. The bowlders here vary in size from four inches to twenty-four inches in diameter. The contemplated improvement is to

do away with the sharp elbows in, and to widen, the present channel there, and to give it a depth of 14 feet below the lowest stage, requiring 27,337 cubic yards, to be removed, as estimated by my assistant, Captain H. C. Wharton, corps of engineers.

The survey of this place was made at my request, in a manner prescribed by myself, by a lake-survey party under the orders of the superintendent of the lake survey, Brevet Brigadier General W. F. Raynolds, to whom I am under obligations for the favor.

2d. At the foot of Sugar Island, 26½ miles below that village.

Map B shows the lines of triangulation and the soundings of the survey which was made by Captain Wharton, under my direction. It is in contemplation to improve here by dredging the space limited between the red lines to a width at bottom from 200 to 300 feet, and to a depth of 13 feet below lowest stage. The material to be dredged is soft clay, and for a width of 200 feet amounts, by this estimate, to 33,888 cubic yards, and for a width of 300 feet to 50,831 cubic yards.

An improvement here is deemed necessary to give a straight free course, allowing vessels to navigate along this part, and a short distance below, without hinderance in the night by taking out two sharp elbows in the present channel, which now cannot be safely run in the dark. In the estimate in my annual report I adopt 300 feet as the proper width for the channel at bottom.

3d. West channel of East Neebish Rapids, 24 miles below said village.

Map C shows the base line and soundings of the survey which was made by a lake-survey party, Assistants Lieutenants Green and Haupt, corps of engineers, placed under my orders for the purpose, in a manner as shown by the map, and which was prescribed by myself.

The improvement in contemplation here consists in dredging so as to widen and deepen where necessary the channel for an extent of 2,100 feet, to a width of 200 and depth of 14 feet below lowest stage during the season of navigation, requiring 3,526.7 cubic yards solid rock, 4,853 cubic yards loose rock, or small bowlders, and 1,627 cubic yards sand and gravel to be removed, as per Lieutenant Haupt's estimate.

It has been considered by all who are acquainted with the river that this improvement will be of vast benefit to the navigation, and I am satisfied that it should be the first improvement to enter upon after completing Lake George Channel.

4th. Middle channel of Lake George, having its middle point say twenty miles below said village.

Map D is a copy, with additions made by Captain Wharton, of the lake-survey map, of a survey made in the fall of 1868, by orders direct from the Chief Engineer to General Raynolds, to whose courtesy I am indebted for permission to make the copy.

This map shows very well the condition of the channel at the close of the dredging in the autumn of 1868. Captain Wharton estimates from it that at the beginning of the season for dredging in 1869 there remained 32,730 cubic yards soft material to be dredged out in order to complete the channel to the scale of improvement contemplated, viz: 14 feet depth in the middle of the channel, 12½ feet at the sides, and 200 feet wide at the bottom.

5th. At a place 1½ mile above the Sault de Ste. Marie Canal.

Map E shows a cluster of bowlders there, which have also been, under my directions, surveyed and located by a triangulation, by Captain Wharton. These bowlders are dangerous, and several vessels have been damaged and two totally wrecked on them in attempting to enter the canal under a strong west wind. By a careful consideration of these sunken dan-

gers I infer, as they have deep water near to and all around them, that by powerful steam force they may be rolled out of the way into deep water; if not, they can be easily blasted, and the fragments moved by a dredge into deep water.

The amount estimated by Captain Wharton of the contents to be removed pertaining to Nos. 1, 2, 3, is only 540 cubic feet to leave us 15 feet depth of water at lowest stage over their remaining parts. Those marked on the map 4, 5, 6, are too remote to be dangerous, and need not be removed.

The cost of the improvement here I estimate, after consultation with experienced blasters, at $3,000.

6th. A bowlder 2¼ miles below the Sault de Ste. Marie Canal. [See engraved map for its location.] This sunken bowlder should be removed. It will cost about $1,000. By dredging a pit near it it probably can be rolled into it; if not, we must resort to blasting.

7th. Another bowlder about 1¼ mile above the head of Ram's Island, which is dangerous to vessels, and should be removed.

8th. Still another bowlder, just opposite the foot of that island.

This is so near the middle of the channel as to be much in the way, and should be removed.

The cost of removing the two last-named bowlders I estimate at $2,000.

No examination or survey has been made with a view of determining the cost of the improvements required in the Sault de Ste. Marie Canal. I think it highly desirable that I should receive authority to do this during the summer of 1869, so that I may set Captain Wharton with a small party at the work before he comes down from there this season.

Respectfully submitted.

T. J. CRAM,
Colonel Engineers, Brevet Major General, June 30, 1869.

Brevet Maj. Gen. A. A. HUMPHREYS,
Brigadier General, Chief of Engineers.

APPENDIX D.

Report of operations in the improvement of Monroe Harbor, Michigan, for the year ending June 30, 1869.

This improvement was under charge of Brevet Major General T. J. Cram, colonel of engineers, until April 12, 1869, after which time its charge devolved upon Major Walter McFarland, corps of engineers.

Nothing has been done here during the past year, the harbor being in very good condition, so far as the piers are concerned, though the bar at the mouth of the ship canal begins to show the need of dredging—although in General Cram's report of last winter he says: "I do not propose to dredge away this bar, there being already water enough for the very limited commerce of the place." On the 14th of June I recommended to the department that the bar at the mouth of this canal be removed by dredging, and that a wing or deflector be constructed at the western extremity of the north pier in order to prevent the seas which run along that pier from breaking through into the channel.

These recommendations were approved by the Chief of Engineers June 18, and on the 31st July I directed advertisements calling for bids for doing this work to be inserted in the Cleveland Daily Herald.

Since the close of the year this work has been let—the dredging at twenty-four cents per cubic yard, which is the lowest bid on public work made within the last five years for this kind of work—and it will probably be completed by the 1st of December.

Balance June 30, 1868	$10,590 21
Expended by General Cram	178 73
Balance June 30, 1869	10,411 48

The most of which will probably be expended within the present year.

No further appropriation is asked.

The annual cost of keeping this harbor in repair may possibly amount to $1,000.

D 1.

Report of operations in the improvement of Toledo Harbor, Ohio, for the year ending June 30, 1869.

This improvement was in charge of Brevet Major General T. J. Cram, colonel of engineers, until April 12, 1869, since when it has been in charge of Major Walter McFarland, corps of engineers.

From July to October 19,100 cubic yards of sand were removed from the channel between buoys 1 and 9, a distance of about one mile and an eighth, in the crookedest and most troublesome part of the channel, in which a depth of twelve feet below low water was obtained for a width of one hundred and seventy feet.

On the 27th of December General Cram transmitted to the Chief of Engineers a project for constructing a ship canal through Maumee Bay at an approximate cost of $885,526, in place of further dredging the channel. This project was submitted to a board of engineers which assembled in Washington in January, 1869, and by them was rejected on the ground of bad location of the proposed cut, defective method of construction, and excessive cost; and in its place it was recommended that the main or western channel should be dredged throughout its entire length, for a width of two hundred feet and a depth of twelve feet, at a probable cost of $152,800, which report and recommendation were approved by the Chief of Engineers in a letter of January 27, 1869, to the Secretary of War, transmitting the proceedings of the board.

Shortly after being placed in charge of the improvement of this harbor I visited Toledo, where I met a number of gentlemen interested in the commerce of the place, and anxious to learn what could be done for the relief of its navigation. In company with them I made an examination of Maumee Bay and of the condition of their commerce, the result of which I reported to the Chief of Engineers on the 6th of May.

I stated in that report that my examination had confirmed me in the opinion expressed by the board in January, that the improvement should be confined to the western or main channel, and that as the dredging would need to be carried over the whole length of it, that not much relief could be given for a less sum than $75,000 or $80,000, which the citizens were very anxious to have allotted from the recent general appropriation of $2,000,000 for the improvement of certain works on rivers and harbors.

In answer to this, on the 24th of May, a letter was sent me from the

office of the Chief of Engineers, directing me to make an examination with the lake-survey steamer Search, of the sailing lines of Maumee Bay, for the purpose of ascertaining "how far $30,000 could be made available toward relieving the present pressure upon the commerce of the place."

This examination was made between the 28th of May and 2d of June, partially delayed by bad weather, during which time upwards of six thousand soundings were taken with a rod over the western channel; the chart of the soundings, made up in Detroit at the office of the lake survey, was received on the 21st, and on the 24th I reported that for $30,000 we could make a channel between sixty and eighty feet in width and of the necessary depth, depending upon the price we should have to pay for dredging, and on the 10th of July I was notified that $30,000 had been allotted for the improvement of this harbor.

Since the close of the fiscal year, on which I am reporting, the contract for dredging this channel has been let to Patrick Smith, of Cleveland, at thirty-five cents per cubic yard, a reduction of ten cents per cubic yard below the price paid for the rest of the dredging at this harbor, and seventeen cents below the price bid by the former contractor for this same work. Three dredges are constantly at work, with the prospect of completing a good sixty-five-foot channel through the bay this fall. To indicate its position I have had its line marked by piles.

There has been expended in the improvement of this harbor during the past year $10,715 51.

Balance June 30, 1868	$13,015 01
Expended by General Cram	10,715 51
Balance June 30, 1869	2,299 50
Allotted since	$30,000 00
Still required to complete the western channel as recommended	120,000 00

Which can all be expended in the present year.

Toledo harbor is in the collection district of Miami, Toledo being a port of entry.

Revenue from customs collected here during the fiscal year ending June 30, 1869	$86,520 79
Number of vessels entered and cleared during same period	5,458
Aggregate tonnage	1,125,539
Crews	43,790

To which statement the collector of the port adds: "If the sand-bar at the mouth of the harbor should be removed, this amount would increase many fold, inasmuch as at present no vessel can enter this harbor at the ordinary stage of water which draws more than *nine* feet. Many of the propellers coming here have to light their cargoes to enable them to enter, while others are deterred from coming here at all. In going out they cannot take full cargoes for the same reason."

D 2.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 27, 1869.

GENERAL: In compliance with the resolution of the House of Representatives, dated January 6, 1869, I forward a "copy of the report of General T. J. Cram, of the Engineer Department, upon the examination and survey for a ship canal on the prolongation of the lower reach of the Maumee River through the shoal water of Maumee Bay, Ohio, directly to deep water in Lake Erie, with plans and estimates of the cost of constructing the same."

In transmitting this report I beg leave to state that the project, as presented by General Cram, has not my approval, being objectionable both as to location of proposed canal and as to plan of construction.

I am of opinion that the depth of water expected to be secured by the construction of this canal not only will not be maintained, but that the work itself will tend to seriously impair the navigation through Maumee Bay, and the present outlet of Maumee River.

In view of the importance of this work, the project of General Cram was submitted to a board of officers of the corps of engineers of special experience in lake-harbor works, who were instructed to * * "Take into consideration the plan submitted by Brevet Major General Cram, dated December 27, 1868, for the improvement of the entrance into the Maumee River, and in so doing consider the relative advantages of continuing the present plan of widening and deepening the track vessels now used in passing through Maumee Bay, and that of a new cut from deep water in Maumee River to deep water in Lake Erie.

"If such a cut or canal is deemed feasible, its proper direction, its width, and the protection required for its banks, will be determined as well as its cost. The cost of executing each project discussed will be submitted.

"The board will determine, as a preliminary step in its proceedings, what increased depth of entrance is required at this harbor for the greater economy and security of lake navigation, in view of the growing wants of commerce."

The report of the board is transmitted herewith. I concur with the board in its deductions and conclusion, "that the improvement of this harbor should be effected by dredging the main or western channel," and have to request that this report may be forwarded to the House of Representatives with the special report called for.

General Cram estimates the cost of the improvement by his project, giving 13 feet depth, at $885,526.

The board estimate the cost of the improvement, using the western channel and giving 13 feet depth, at $124,212.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers Commanding.

Major General J. M. SCHOFIELD,
Secretary of War, War Department.

Report upon the examination and survey, with plans and estimates, of the cost of constructing a ship canal in the direction of the prolongation of the lower reach of the Maumee River, directly across the shoal, Maumee Bay, into deep water of Lake Erie; by Brevet Major General T. J. Cram, colonel corps of engineers, in accordance with authority from the Chief Engineer, dated September 1, 1868.

1. REASONS FOR CONSTRUCTING THIS PROPOSED SHIP CANAL.

In my annual reports of 1867–'68, cogent reasons have been urged for stopping further expenditures upon the plan of widening the vessel tracks as they now pass through the bay, and deepening them to 12 feet, as we have been doing the past two seasons, under the appropriations of 1866–'67, amounting to $40,000.

The examination and survey, continued up to the close of the present dredging season, give us the data for arriving at the measure of the advantages and disadvantages to be expected from continuing the present plan of improvement, which I will here briefly present:

On chart A I have located this improvement by the red dotted lines extending from buoy No. 9—the present mouth proper of the river—to buoy No. 7, a distance of 1⅛ mile, in which we have dredged, so that we now have 170 feet width and 12 feet depth of channel in low water of the season of navigation, excluding those occasional gales from the west, when the water is blown from the bay, so as to lower it by 3 to 4 feet.

The total amount dredged for this improvement has been 82,469 cubic yards, including dredging away the troublesome elbow near the mouth, the whole costing under the contract $35,200 50.

It is very true that this improvement has relieved the navigation very much of the difficulties vessels have heretofore encountered in this reach, so much that none have been reported as having grounded here this season. The difficulties now are further out on both vessel tracks, where, in several places, the shoalness is such that they frequently ground in adverse winds, at the angles of the tracks, mostly, but sometimes even in the straight parts of the courses. These groundings became so frequent that I directed the inspector of dredging to keep a record of the number and time of detention of all that should come under his observation. His report has been rendered and shows that from the 15th of August to the 18th of November, 1868, 102 vessels grounded, and the average detention for each was 13½ hours; some were detained as long as 48 hours. These detentions, bear in mind, occurred in only three (3) months of the season of navigation. It is difficult to estimate the money loss, to ship and freight owners, of these detentions.

My examinations have also been extended to the questions of damage, lighterage and lights required by reason of the shoalness of the water, and the angles, or crookedness, of these vessel tracks; and I cannot set their aggregate measure in cost at less than $25,000 per season. Others set it much higher.

To estimate the cost of completing the improvement by the mode we have been pursuing for the past two seasons, by dredging these tracks to a depth of 12 and width of 200 feet, I take as a basis of calculation the cost of what we have already accomplished, premising that for each mile as we should go further out, the expense of dredging, from increased risk of the dredges, tugs, and scows being driven away, and detention by the frequently passing vessels, would increase in the ratio of 20 per cent. for every successive mile over the cost of the preceding mile.

Upon the foregoing basis I make the cost of dredging for completing the eastern track.............................. $423,386 00
And of the west track.............................. 252,710 00
And of completing both without any dikes............... 676,096 00

Should one be improved without the other there would be times when no vessel could pass in or out; hence discontent, unless both should be improved, and it would be necessary to improve both if we expect by this plan to render the bay a fit harbor of refuge in all weather. The east channel would be 6.811 miles long between the river's mouth and lake, and the west 4.943 miles long. And after dredging them to this cost, they would most undoubtedly fill up within a few years; and their angles, or crookedness, at all times would be serious hinderances to the passage of vessels under strong winds from almost any quarter.

2. PROPOSED STRAIGHT SHIP CANAL.

The examination and surveys which have been especially made for this, lead us to a location for the canal represented in fine red lines, extending from 13 feet depth of water in the lower reach of the Maumee River, as seen on Chart A. This chart shows the soundings made twelve years since. Map B also shows the location of the canal, and the soundings and borings made in September and October, 1868. On a careful comparison I find that near the mouth of the river and for some distance out, there has been a filling up in the past twelve years for at least 18 inches; but as we go further out, and especially out into the lake beyond North Cape Point, the changes have not been so great. It is impossible to compare with mathematical nicety the soundings of our recent with those of the former survey—owing to the bench mark of Chart A not having been recovered; it has been lost, as mentioned on the chart. In our estimates, therefore, we are to be guided not by Chart A, but by Map B, whose plan of reference for the soundings is the surface of the water at the low stage during the season of navigation, excluding the extraordinary fluctuations already referred to. Another point: Our examinations clearly show that without much greater expense the new canal cannot be made with more than 13 feet depth of water below this low stage—which has been fixed and marked as our "standard stage;" and this is the stage designated "surface of water" in the drawings accompanying this report.

There will be three divisions of the canal, viz:

1st division—from C, which we have permanently located in mouth of the river, to D, at the shore line of the cape on the bay side, an extent of 4,720 yards.

2d division—from D across the ground of the cape, which is above water, to *d′* at the lake shore line, an extent of 360 yards.

3d division—from *d′* to *d″*, which is a point in 13 feet water in the lake, an extent of 2,270 yards.

Therefore, from 13 feet water in mouth of the river to 13 feet water in the lake, the total length of the proposed canal will be 7,350 yards, or nearly $4\frac{1}{10}$ statute miles.

The mean of all the soundings in 1st division is 8.12 feet.

The mean rise of ground above water in 2d division is 1.15 feet.

The mean of all the soundings in 3d division is 8.518 feet.

CROSS SECTION OF PROPOSED CANAL.

In my judgment, for the present and for some years to come, the wants of the general commerce for refuge, and the immediate commerce of Toledo, would be amply provided for by making the canal 200 feet wide at bottom and 260 feet at the water surface, in 1st division; and 300 feet wide at bottom and 252 feet at water surface, in 2d division; and 250 feet wide at bottom and water surface in 3d division.

On the east, or bay side of the canal, in 1st division, there should be constructed of wood, with the earth dredged from the canal, a good dike, or revetment, with its face next the canal, vertical—to prevent the heavy bay waves coming from the east, from breaching through the canal bank into the canal; on the land side such a revetment would not be necessary. The canal side there should have a slope and berm; the slopes to be 1 on 2. This, in after time when increased commerce will need it, would allow the canal to be widened 25 or 50 feet, without sacrificing any of the first construction.

On both sides of 2d division there should be slopes of 1 on 2, then a berm and an embankment; there would be no necessity of revetments, or defensive dike like that for the 1st division.

On both sides of 3d division parallel piers should be extended out *at first* into the lake only to 10 feet water, having a width of 250 feet between them. This would be for the outer harbor of refuge, and a greater width I think unnecessary, and it would for all time satisfy the increasing wants of the commerce. The earth, however, must be excavated in this division to allow the cribs of the piering to stand in 13 feet water; and that excavated from between the piers to be used in part for filling the cribs up to the water surface, the remainder of the pier filling to be of rubble stones, and the remainder of the earth excavation to be thrown over back of the piers and put in proper shape. Of course, the dredging for the canal is to be extended beyond the piers, to the 13 feet curve in the lake.

Sheet C shows the cross sections in each division in all the mathematical details and dimensions, drawn to a scale and with an "equalization of excavation and embankment." The tops of the banks in each division are to be 5 feet above the surface of the water.

The excavation in 1st division would be..	540,450 cubic yards.
The excavation in 2d division would be..	129,218 cubic yards.
The excavation in 3d division would be..	347,012 cubic yards.
Total excavation for the canal and piers,	1,016,680 cubic yards.

The embankments for the 2d division require only 15,308 cubic yards to make them; the surplus of 113,910 cubic yards is to be brought back to help make the west embankment of 1st division. The mean distance this surplus will have to be moved is 1⅜ mile, all by water.

The borings at six different places along the line of the location, show that the material to be dredged is just what contractors desire for their machines to work in, and that it is of very easy nature for dredging. It is also good for driving piles into and holding them after being driven.

The design for the wood work of the dike, first division, is shown in all necessary details in sheet D; it is essentially the same as that which in every respect has proved perfectly successful for the new St. Olan flats improvement, and we need have no hesitation in adopting it for the Maumee construction. Even though the waves should wash

away the earthen part of the embankment the wood work would remain intact and its sheet piling would prevent the earth from being driven into the canal. I think it would be quite sufficient to make this revetment for an extent only of 11,610 feet.

The pier work in third division I would only at first extend from d' to the 10-feet curve—a distance of 1,300 yards—but dredge out to the 13-feet curve as before stated, waiting to see whether it would be necessary afterward to extend the piers further out. In my opinion the power of the outflow of this river through such a channel would keep the new canal clear of deposits quite out beyond the 13-feet curve, after dredging out to that depth, without prolonging the piers. The force of outflow is a question to which our examination and survey were extended, and my assistant, Captain G. I. Lydecker, corps of engineers, presents the following results of his experiments upon this subject:

"In the reach chart A from red buoy No. 6 to black buoy No. 13, a distance of 1,300 yards, he found the surface velocity to be 0.39 mile per hour; and by a float extending below the surface 0.20 mile per hour—a light southwest breeze blowing during the experiments."

He is of the opinion that under ordinary "circumstances the current in the lower part of the river is mainly if not wholly due to the winds. Thus a strong northeast wind breaks the water from the lake and bay up the river, giving, as long as it lasts, a strong current, uprising the water in the bay and lower reach of the river from 2 to 3 feet above its ordinary level. When the lull comes the water rushes out to re-establish the equilibrium and a strong down current results. And, *vice versa*, a strong wind from the southwest produces corresponding but opposite currents to those mentioned above as due to a northeast wind. During the day and night previous to his experiments a strong southwest wind had prevailed and the water in that reach and bay had fallen 10 inches.

"But in freshets, especially those of spring-time, the outflow is very powerful, notwithstanding the winds from the quarters mentioned, and outward currents obtain for seven to ten days."

The effect of these in clearing the canal, if properly made from deposits, would undoubtedly be successful. On the contrary, such an effect can never be hoped for in a division of the force of this outflow between two crooked channels, such as we have at present and should continue to have by improving ever so much the east and west vessel tracks. The view I take in respect to filling the piers of the third division, is to fill the lower parts with stone ballast for a height of three feet, thence to the water surface with the materials we dredge from the water-way between the piers, and thence four feet higher, with rubble stone to the bottom of the upper timbers of the superstructure. The cribs should be fastened in place by a pile driven in each interior corner. The effect of which I know from my own experience, when the piles are properly driven, would be to keep the cribs from careening while they settle. In this locality the borings lead to the belief that after dredging to a depth of 13 feet, the foundations will admit of close bottoms to the cribs. Should it be found otherwise in the process of construction, the tight flooring could be left out and the cribs would then have a single grating bottom. Sheet E shows the drawings of the cribs and superstructure.

Approximate estimate of the cost of the canal.

Item 1. Dredging 1,016,680 cubic yards earth in all the divisions, and putting the same into dike piers and banks, as shown by the drawings on sheet C, at 30 cents per cubic yard	$305,004 00
Item 2. 11,610 running feet of revetment in first division, as shown on sheet D, materials at $6 92, and labor of construction at $4 12 per running foot of dike	128,174 00
Item 3. 7,800 running feet of piering in third division, shown in construction on sheet E, material at $35 91, and labor of construction at $10 97 per running foot of piering	365,664 00
	798,842 00
Contingencies, including services of inspector at 5 per cent	39,942 00
"Creosoting" all the wood above water to preserve it from decay—311,610 cubic feet, at 15 cents per cubic foot	46,742 00
Total	885,526 00

3. COMPARISON OF METHODS OF IMPROVEMENT.

In chapter I the estimated cost of dredging out the present west vessel track to a width of 200, and a depth of 12 feet, is $252,710, and for the east track it is $423,386.

Now, if, as we dredge out an entire new channel to a width of 200 feet at bottom, and to a depth of 12 feet along the straight course upon which it is proposed to locate the canal, throwing the dredged earth out to the right and left, or getting rid of it as we should do by dredging either or both of the present tracks, the amount of dredging in all three of the divisions, from 12 feet water in the river to 12 feet water in the lake, would be 647,637 cubic yards, which, at 30 cents, would cost $194,291, being less by $58,419 than the cost of the west, and less by $229,095 than that of the east track. The total length of the straight channel to be dredged would be 6,670 yards, equivalent to about 3¾ miles.

Such an improvement without revetment in the first, and without piers in the third division, would be liable to fill, notwithstanding the outflowing force, but not so liable as the east or west track would be; and the straight channel would afford much better ingress and egress for vessels than either or both of the present tracks could offer, if dredged out to their full lengths.

I have the honor to be, very respectfully, your obedient servant,

T. J. CRAM,
Colonel Engineers, Brevet Major General.

Brevet Maj. Gen. A. A. HUMPHREYS,
Brigadier General, Chief of Engineers U. S. A.

D 2.

Proceedings of a board of engineers convened at Washington, D. C., in obedience to the following order:

[Special Orders No. 2.—Extract.]

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 14, 1869.

* * * * * * * * * * *

3. A board of engineers for the consideration of the improvement of the entrance to Toledo Harbor, Ohio, consisting of the following named officers of the corps of engineers, namely: Colonel John N. Macomb, brevet colonel United States Army; Colonel James H. Simpson, brevet brigadier general United States Army; Lieutenant Colonel Israel C. Woodruff, brevet brigadier general United States Army; Major J. B. Wheeler, brevet colonel United States Army; Major Walter McFarland, brevet major United States Army, will assemble in the city of Washington, D. C., as soon as possible after the receipt of this order.

By command of Brigadier General Humphreys:

THOS. LINCOLN CASEY,
Major of Engineers and Brevet Colonel United States Army.

SATURDAY, *January* 16, 1869—12.30 p. m.

The members having met in pursuance of the above order—present, all the officers therein named—the board was organized by the reading by the senior member, Colonel John N. Macomb, brevet colonel United States Army, president of the board, *ex officio*, of the order of assembly given above, and at once proceeded to business.

The following letter of instructions from the Chief of Engineers was laid before the board and read to it:

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., January 16, 1869.

COLONEL: The board of engineers convened in pursuance of Special Orders No. 2, headquarters corps of engineers, January 14, 1869, for the consideration of the improvement of the entrance to Toledo Harbor, Ohio, will take into consideration the plan submitted by Brevet Major General Cram, dated December 27, 1868, for the improvement of the entrance into the Maumee River, and in so doing consider the relative advantages of continuing the present plan of widening and deepening the track vessels now use in passing through Maumee Bay, and that of a new cut from deep water in Maumee River to deep water in Lake Erie.

If such a cut or canal is deemed feasible, its proper direction, its width, and the protection required for its banks, will be determined as well as its cost. The cost of executing each project discussed will be submitted.

The board will determine as a preliminary step in its proceedings what increased depth of entrance is required at this harbor for the greater economy and security of lake navigation, in view of the growing wants of commerce.

Brevet Brigadier General I. C. Woodruff will be instructed to pay the expenses incurred by the board of engineers, including mileage of the members to Washington and returning to their stations, from the appropriation for examination and survey on the northwestern lakes.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers Commanding.

Colonel J. N. MACOMB, *Corps of Engineers,*
President Board of Engineers, Washington, D. C.

The original "plan submitted by Brevet Major General Cram, dated December 27, 1868, for the improvement of the entrance into the Maumee River," was then laid before the board, read, and partly discussed, after which the board adjourned to meet on Monday, January 18, 1869, at ten o'clock a. m., at the same place, room No. 18 Winder's Building, Washington, D. C.

WALTER McFARLAND,
Major of Engineers, Recorder ex officio.

MONDAY, *January* 18, 1869.

The board met pursuant to adjournment, and resumed the consideration of the scheme of improving the entrance to Toledo Harbor, Ohio, recommended by General Cram.

After examining the lake survey charts of this harbor, showing its condition in 1844 and 1857, and comparing the soundings given thereon with those furnished by General Cram; also examining the records of the imports and exports at this port for several years back, the board, after further discussion of the various features of the scheme, adjourned at half-past three, to meet again on Tuesday, January 19, 1869, at ten o'clock a. m., at the same place.

WALTER McFARLAND,
Major of Engineers, Recorder ex officio.

TUESDAY, *January* 19, 1869.

The board met at the time and place appointed; resumed the investigation of the matters submitted to its judgment, and at two o'clock p. m. adjourned to meet at ten o'clock a. m. on the succeeding day at the same place.

WALTER McFARLAND,
Major of Engineers and Recorder ex officio.

WEDNESDAY, *January* 20, 1869.

The board met at the hour and place appointed, and resumed the consideration of the subjects before it; and after deliberating upon them adjourned at half-past three o'clock p. m. to meet the succeeding day at the usual place at ten o'clock a. m.

WALTER McFARLAND,
Major of Engineers and Recorder ex officio.

THURSDAY, *January* 21, 1869.

The board met pursuant to adjournment and proceeded to the completion of the business before it.

After due deliberation the board submit the following opinions and recommendations in regard to the improvement:

OPINION, ETC.

The board is of the opinion that the depth of water recommended by General Cram, viz: thirteen (13) feet below lowest water of the season of navigation, excluding storm tides from consideration, is sufficient for the present and prospective wants of this harbor, as indicated by the published records of its imports and exports.

The plan of a straight cut or canal, as proposed by General Cram, is, in the opinion of this board, very defective and highly objectionable, both as to location of the cut, in the details of its construction, and in the magnitude of its cost.

This plan contemplates a canal with embanked and partially revetted sides, four and one-tenth ($4\frac{1}{10}$) miles long, not less than two hundred (200) feet wide at the bottom, with a depth of thirteen (13) feet, beginning near a point marked on the map herewith as buoy No. 9, near the mouth of the Maumee River, and extending into Lake Erie in a northeasterly direction to the thirteen (13) feet curve.

The estimated cost of executing this project is $885,526.

In locating this canal, General Cram appears not to have considered

the flow of water from the Ottawa River, which empties into Maumee Bay, near to and west of North Cape Point.

This river drains between three hundred and four hundred square miles of country, and at times must pour a large volume of water into Maumee Bay. The exact quantity of this flow is not known.

If this canal proposed by General Cram be built, its dikes would form a dam directly across the natural course of the outflow from this river. This dam or obstruction would certainly be carried away unless made stronger than proposed in the plan submitted; and, if so strengthened as not to be carried away, would deflect the waters of the Ottawa from their natural course, and cause them to flow around the inner end of the canal. This current meeting the current of the Maumee River, would prevent its entrance into the canal, and the scour through the canal, upon which General Cram lays so much stress, would be lost and the mouth soon fill up.

The construction of this canal would result in actual injury to this harbor as one of refuge; for the main entrance into Maumee Bay, called the main or west channel, immediately west of Turtle Island light, is nearly half a mile wide, with thirteen (13) feet depth of water, and affords a good roadstead for vessels seeking shelter here, for they are protected from northeast gales, which in this part of the lake are the most dangerous, by Turtle Island and the shoals extending to the southward and eastward of it. Vessels seeking shelter from westerly gales may anchor with safety either inside or outside of Maumee Bay.

These advantages as a natural harbor of refuge, which Maumee Bay now offers, would be endangered by the construction of the proposed canal, supposing a current to pass through it as General Cram asserts it would, for its effect would be to cause a deposit and gradual shoaling of water in this harbor of refuge.

If, however, it were decided to construct such a canal, the project of embanking should be discarded, and its sides should be constructed in such a manner as to avoid being destroyed by the wash of the sea. The parts exposed to the bay, and those north of North Cape Point, should be composed of cribs ballasted with stone.

A canal constructed in this manner would far exceed in cost the estimate furnished by General Cram.

For these reasons the board would recommend the rejection of the plan.

Before passing to the consideration of any other plan of improvement, the board desires to express its decided disapproval of the suggestion made by General Cram of throwing the material, as dredged from the bottom of the cut, into the cribs, or of using tight bottoms in those cribs.

Neither does the experience of the board confirm the assertion of General Cram, that piles driven in the corners of a crib filled with stone, keep it from careening while settling; for there are numerous well established instances of their failure to do so.

General Cram lays stress upon the necessity of improving the east channel, in order to prevent discontent, and estimates the cost of the improvement at $423,386.

The board not only does not agree with him as to the necessity of making this improvement, but is decidedly of the opinion that any such attempt at improvement would probably result in injury to the harbor.

General Cram estimates the cost of improving the main channel, or west track, as he calls it, $252,710, for a width of two hundred (200) feet and a depth of twelve (12) feet. The board, however, finds that to give the

western channel, from the deep water of Maumee River to the thirteen (13) feet curve in the lake, the same width of two hundred (200) feet, and a depth of thirteen (13) feet instead of twelve (12) feet, would require the excavation of 382,000 cubic yards of material, (throwing out of consideration the 82,000 cubic yards which General Cram reports as already excavated,) which, at forty (40) cents per cubic yard, a liberal estimate compared to current rates, would amount to $152,800; a reduction of about $100,000 below his own estimate.

A careful comparison of the surveys of this harbor, made in 1844 and 1857, in relation to the soundings given thereon, and those furnished by General Cram, shows that while in this period of thirteen (13) years there has been, as was to be expected, a slight shoaling on the banks, the channels thamselves have not materially changed; whence it is inferred that no serious filling is to be apprehended if the waters of the Maumee and Ottawa are permitted to flow through the channels which they have made for themselves—while the consequences of attempting to divert them into other courses can only be known by trial, and experience shows are quite apt to be different from our preconceived notions of them.

It is the opinion of the board, in conclusion, then, that the improvement of this harbor should be effected by dredging the main or western channel; and for this purpose the board would recommend the building of first-class dredging machines, to be worked by hired labor.

The cost of the machines necessary for accomplishing this purpose in the best and most economical manner would be as follows, viz:

Three dredging machines, at $13,500 each	$40,500
Six dump-scows, at $1,250	7,500
One flat scow	600
One steam tug	8,000
Total	56,600

These three machines and the tug could be operated for one hundred dollars ($100) per day.

Ten (10) per cent. per annum on their original cost would keep them in repair and in working order.

They would dredge in the aggregate, at the lowest estimate, one thousand (1,000) cubic yards per day, and would therefore accomplish the work required of them under the least favorable conditions, in three hundred and eighty-two (382) working days.

The entire cost of the improvement, then, would be as follows, viz:

First cost of machines	$56,600
Repairs, ten per cent. per annum say for two years	11,320
Cost of working would not exceed	45,000
Total	112,920
Add ten per cent. for contingencies	11,292
Aggregate cost	124,212

Thus, for two years' interest at seven per cent. on the amount of General Cram's estimate, the entire work could be completed, and the United States would at the close be in possession of $56,600 worth of

machines, which could be applied to the keeping open the channels here and elsewhere on the lakes, if necessary.

Even were it necessary to work these machines *annually* in order to keep this channel open—which, from the almost unchangeable nature of this bay, it is quite certain would not be the case—the annual cost of running them and keeping them in repair would be but a trifling part of the yearly interest on the excess of the amount of General Cram's estimate over the original cost of these machines.

All of which is respectfully submitted.

J. N. MACOMB,
Col. of Eng'rs, Bvt. Col. U. S. Army.
J. N. SIMPSON,
Col. of Eng'rs, Bvt. Brig. Gen. U. S. Army.
I. C. WOODRUFF,
Lieut. Col. of Eng'rs, Bvt. Brig. General.
J. B. WHEELER,
Major of Engineers and Brevet Colonel.
WALTER McFARLAND,
Major of Eng'rs and Bvt. Maj. U. S. Army.

There being no other business before it, the board adjourned *sine die.*

J. N. MACOMB,
Col. of Eng'rs, Bvt. Col. U. S. Army.

WALTER McFARLAND,
Major of Eng'rs and Bvt. Maj. U. S. A., Recorder.

UNITED STATES ENGINEER OFFICE,
Erie, Pennsylvania, May 6, 1869.

GENERAL: In my recent trip to Toledo and Maumee Bay, made in conformity with the instructions of Special Order No. 34, Headquarters Corps of Engineers, dated Washington, D. C., April 26, 1869, I met many prominent merchants, ship-owners, and others interested in the welfare of the city and its harbor, and anxious to ascertain what was to be done for them out of the recent general appropriation for river and harbor improvements.

In company with a delegation of these gentlemen, I examined, as well as my limited time would permit, the channel through the bay and its surroundings; and the result of that examination was simply to confirm me in the conclusions reached by the board of engineers of which I was a member, convened in January last, "for the consideration of the improvement of the entrance to Toledo Harbor, Ohio."

In respect to the growth and progress of the city, however, and the value of its commerce, upon which it is presumed the amount of the allotment to be made for the improvement of its harbor must depend, an erroneous impression has prevailed, due to a table contained in the "Toledo Blade's annual statement of the trade and commerce of Toledo" —which shows a marked and constant decrease in the grain trade of the city from 1862 to 1866—which decrease was attributed to the diversion into other channels of a portion of the grain trade, upon which the prosperity of Toledo largely depends. This, it is admitted, is partly true; owing to the opening of the Mississippi and the demands of the southern markets, which had been closed in the earlier years of the war; but it is claimed that all the lake cities suffered similarly, and that Toledo suffered less than the others relatively. The loss of the wheat crop in the

Wabash valley in 1865–'66, was a severe blow to the city, keeping its trade below even what it had been in the four preceding years; but from all this the city is rapidly recovering, as is shown by the fact that its receipts, which from 11,674,120 bushels of grain, 1,383,889 barrels of flour in 1861, had fallen to 7,914,800 bushels of grain, 736,207 barrels of flour in 1866, have grown again to 11,280,575 bushels of grain, 868,524 barrels of flour, in 1868. These figures are taken from the last published report on the trade and commerce of the city.

In respect to population the city's growth has been remarkably rapid. In 1860, the population was 12,800; in 1865, 24,400; in 1867, 31,651; and in 1868, between 35,000 and 36,000 are claimed, and the claim seems to be sustained by the fact that 5,600 votes were polled at the last election. In 1867, over 1,300 dwelling houses were erected. In 1868, over 1,500, and nearly all are occupied.

Judging from these facts and from the active spirit everywhere manifested by the inhabitants, as shown by the improvements in progress all over the city, I think that Toledo must be regarded as one of the most rapidly growing of our many growing western cities.

The greatest obstruction to its progress is to be found in the insufficient depth of water in the channels through Maumee Bay, which causes frequent groundings of heavily laden vessels entering and departing, and of course long delays and useless expense. While examining the bay on Monday last, two large steamers, here at the very commencement of navigation, ran aground and were being lightered. Of course the annoyance, inconvenience, and loss of money consequent upon this, injuriously affects the interests of the city, by keeping many vessels and traders away, and yet in spite of these obstacles the place grows.

To put the entrance to this harbor into proper condition, I think the method of improvement recommended by the board of engineers above referred to should be carried out.

The estimate for improving the western channel was, if done by government machines, including their cost, \$124,212; if done by contract, at forty (40) cents per cubic yard, \$152,800.

It is possible that on account of the exposed position of the channel to be dredged, extending from the Black can-buoy, where General Cram left off dredging, to near Turtle Island light, a distance of three and a half (3½) miles, and the delays to which the machines would probably be subject by reason of rough weather, these estimates may be too low, and I think that not less than \$150,000 should be appropriated or allotted for this purpose; that is, to give a channel two hundred (200) feet in width. From the nature of the bottom, too, which is nearly level throughout this whole distance, no relief can be given to the commerce of the place except by dredging this channel deeper over its entire length, and for a width of not less than one hundred (100) feet; the cost of which would not fall short of \$75,000 or \$80,000, and if this amount can be allotted to Toledo, I think it should be done. No smaller amount will be of much avail.

The anxiety of the citizens to have something determined in respect to their harbor has induced me to make this report, though, under circular of April 5, from your office, the matter properly came within the province of General Cram.

Very respectfully, your obedient servant,

WALTER McFARLAND,
Major of Engineers.

Brevet Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

D 3.

Report of operations in the improvement of Sandusky River, Ohio, for the year ending June 30, 1869.

Upon an examination of this river in April, after the charge of its improvement had been devolved upon me, it was found that the chief impediments to its navigation were at the first shoal place below Whitacie bar, referred to in General Cram's report upon this river as *secondary place No.* 2, at Squaw Island, and at the mouth of the river. I accordingly directed that the first and second points mentioned should be dredged to the width of sixty feet and two feet below the bottom, and that the balance of the appropriation should then be applied to the improvement of the bar at the mouth of the river; which was accordingly done, affording considerable relief to the vessels navigating the river. In this operation 13,704 cubic yards of material were removed, 13,649 cubic yards having been previously removed under General Cram's orders from Whitacie bar and from the bar at the mouth of the river. This gives a good eight foot channel from Fremont to the mouth of the river, and entirely exhausts the appropriation.

The estimated cost of making this a twelve-foot channel was $35,000. Until there is a good twelve-foot channel through Sandusky Bay, which is not now the case, it would be useless to give twelve feet depth in Sandusky River. But $20,000 could be well expended here in widening the present sixty-foot channels and deepening them so as to admit of the passage of the heaviest vessels that can navigate Sandusky Bay.

Balance June 30, 1868		$8,340 21
Expended by General Cram	$4,084 77	
Expended by Major McFarland	3,906 00	
		7,990 77
Balance June 30, 1869		349 44

D 4.

Report of operations in the improvement of Sandusky City Harbor, for the year ending June 30, 1869.

Since the close of the last fiscal year, 17,685 cubic yards of sand have been removed from the outer bar, and when carefully examined in June last, the channel was found to be 240 feet in breadth with over twelve feet depth of water on it except in two places on the south side of the cut, one 60 feet by 100 feet, the other 100 feet by 200 feet, the smaller dimensions running crosswise to the channel, on which the water is but eleven and a half feet in depth. It is probable that these spots were never cut out to the proper depth.

It will be remembered that the original design was to dredge this channel to 400 feet width. I learned, however, upon making my first examination of this harbor in April last, that there was more water on the outer bar than there was just inside the harbor, and that the merchants and ship-masters of Sandusky City were desirous of having the balance of the appropriation for the improvement of this harbor, applied exclusively towards deepening the channel over this inner bar, being perfectly satisfied with the condition of the outer channel.

I accordingly recommended that this balance should be so applied, which

recommendation, upon the evidence furnished by long and careful surveys extending into July, was approved by the Chief of Engineers, July 29. The work was accordingly advertised, bids opened August 30, to which time a recent order of the War Department compelled us to put off their examination, and the dredging was let to Patrick Smith, of Cleveland, at thirty-three and a half cents per cubic yard, a reduction of forty-one and a half cents on the price paid for dredging on the outer bar and an advance of six and a half cents on the price paid for dredging in Sandusky River.

The work will be begun this fall and carried as far as the weather will permit. The price at which the contract is let is so much lower than the rates which have ordinarily been paid, and by which I had made my estimates, that I find we shall be able to make the channel one hundred and fifty feet wide, instead of one hundred, which was all I hoped for.

It should, however, be widened still another hundred feet, the cost of which may be estimated at $10,000.

Balance on hand June 30, 1868		$24,353 76
Expended by General Cram	$13,894 90	
Expended by Major McFarland	93 80	
		13,988 70
Balance June 30, 1869		10,365 06

all of which will be expended in the deepening of the channel over the inner bar during the present year. Still needed for this purpose, $10,000. This will complete the improvement of this harbor for twelve feet depth of water, though probably it will be necessary periodically to remove deposits from both channels, the cost of which has been estimated at $2,500 annually.

Sandusky Harbor is in the collection district of Sandusky, Ohio, Sandusky City being the port of entry. During the year ending June 30, 1869, there had been collected from customs a revenue of $9,792. Number of vessels which had entered and cleared, foreign, 191; coastwise, 5,487.

D 5.

Report of operations in the improvement of Huron Harbor, Ohio, for the year ending June 30, 1869.

This improvement was under charge of Brevet Major General T. J. Cram, colonel of engineers, until April 12, 1869, when it was placed in charge of Major Walter McFarland, of the same corps.

Nothing has been done in the improvement of this harbor during the past fiscal year; since its close, however, estimates of the cost of necessary repairs in both piers have been made, advertised, and the work let, to be completed this fall.

Balance June 30, 1868	$13,774 31
Expended by General Cram	200 95
Available June 30, 1869	13,573 36
Probable cost of repairs to be made this fall	2,500 00
Leaving	11,073 36

to be applied to further repairs as the necessity for them arises, which will not probably amount to more than $1,500 per year.

No further appropriation is asked. Huron Harbor is in the collection district of Sandusky—Sandusky City, Ohio, being the nearest port of entry. Revenue collected for the year $37. Number of vessels entered and cleared, coastwise, 103.

D 6.

Report of operations in the improvement of Vermilion Harbor, Ohio, for the year ending June 30, 1869.

This improvement was under the charge of Brevet Major General T. J. Cram, colonel of engineers, until April 12, 1869, since which time it has been under charge of Major Walter McFarland, same corps.

Nothing has been done here since the close of the last fiscal year, the piers being in very good condition, and giving no indications of needing further repairs very soon.

The appropriations and allotments for this work are exhausted, and there is no immediate necessity for any others. Probable annual cost of keeping the piers in repair $1,000.

Vermilion is in the collection district of Sandusky—Sandusky City being the nearest port of entry. Revenue collected from customs for the year ending June 30, 1869, $82. Number of vessels entered and cleared, coastwise, 191.

D 7.

Report of operations in the improvement of Black River Harbor, Ohio, for the year ending June 30, 1869.

This improvement was in charge of Brevet Major General T. J. Cram, corps of engineers, up to and including April 12, 1869; after which it was in charge of Major Walter McFarland, of the same corps.

As in the preceding year nothing has been done here, the harbor being in sufficiently good condition.

Since the close of the year, however, slight repairs to the west pier have been found necessary, estimates made, the work advertised and let, and it will be completed probably by the end of October.

It is reported that there is twelve feet water on the bar; and allowing one foot and a half for the usual height of the lake, we should have water enough for vessels drawing ten feet; while, according to General Cram's report of last winter, there was only depth enough to allow vessels drawing eight feet to pass.

Balance on hand June 30, 1868, being the entire appropriation of 1866	$10,000 00
Expended (office)	24 58
Available June 30, 1869	9,975 42
Probable cost of repairs to be done this fall	1,500 00
Leaving for future repairs	8,475 42

No further appropriation is needed.

Black River Harbor is in the collection district of Cuyahoga, Ohio, and the year ending June 30, 1868, there was collected here from customs	$62 50 currency.
Port of Black River	22 00 coin.
	84 50

No statistics are given for the year just passed, for the reasons stated in my annual report on Conneaut Harbor, Ohio.

D 8.

Report of operations in the improvement of Cleveland Harbor, Ohio, for the year ending June 30, 1869.

The west pier, which at the close of the last fiscal year had been extended four hundred and fifty feet, has been extended fifty feet further, and completed.

The east pier had been extended three hundred and eighty-five feet by the beginning of December last, when the setting in of winter brought our operations to a close.

By the end of June this pier had been extended to something over four hundred feet beyond the end of the beacon pier, and by the close of September it will be completed throughout its entire length of five hundred and seventy-five feet.

These extensions, it will be recollected, consist of the pile pier designed or claimed by General T. J. Cram, and for which mode of construction he claimed a great saving in cost over the old method of crib construction, which has been employed on the lakes for the last forty or fifty years.

This method of construction, being an experiment only, was authorized by the Engineer Department only on the score of the great economy claimed for it, and then only for situations where the existence of a clay substratum furnished reasonable ground for expecting that the piles, which constitute the chief feature of this system, would retain their places after being driven.

I now propose to show that this system is neither as strong nor as durable as the system of crib construction; that it is almost impossible to repair any injury to the under-water portions, except by clumsy patchwork; and, from evidence that cannot be disputed, that the cost is actually greater than that of an equal amount of crib-work.

It is not as strong as the crib construction because in twelve feet depth of water the points of bearing of the piles, supposing the sand at one extremity and the sill and binder at the other may offer resistance enough to entitle them to be called points of bearing, are eleven and a half feet apart, while in the crib construction the ties which bind the side timbers together, thus constituting points of support, are but ten feet from center to center. The piles, again, are independent of each other, while the side timbers of the cribs are bolted to each other at about every two feet of their length, so that each receives direct support from the first and second timbers both above and below it, and indirect support from all the others.

The center of pressure being at the same distance beneath the surface in both cases, (taking the average in case of the timbers,) we have, in

order to resist the cross strain, in one case, a round 12-inch pile with points of support eleven and a half feet apart, and in the other case, a square 12-inch timber with points of support at the ends ten feet apart, and at every two feet along each side.

To suppose any greater depth of water, or to take the clay into which the piles penetrate instead of the sand as the lower point of support, makes the case still worse for the piles.

But, again, the points of support in the crib construction are firm and unalterable, the resistance which they offer being due to the tensile strength of the ties; while in the pile pier, as designed for Cleveland, the point of support at the lower end is sand, and at the upper end two timbers, a sill, and binder, the former 6 by 12 inches, and the latter 4 by 8 inches, each placed with its smaller dimension in the direction of the cross strain which it is intended to resist, and fastened at every five feet by a bolt passing through the longer dimension of the sill into the lower timber of the superstructure, which, being between the high and low water levels, is subject to wet rot.

Against the impact of a vessel it offers nothing like the resistance of the crib construction; for, the resistance of the superstructure and of the stone filling being the same in both cases, we have in addition, in one case, the resistance of only one or two piles, while in the other we have every timber of the superstructure lending its aid to resist the cross strain to which they are subjected.

All this is supposing that the pier can be constructed just as it was designed; but at Cleveland, at least, this cannot be done. It is found to be simply impossible to drive the piles either in contact or in the same vertical plane. The consequence of the former is that openings occur at the bottom, through which the stone filling leaks out, and which it is not easy to close.

In the latter case, the contractors at Cleveland have been compelled to employ jack-screws, and even a tug, in order to haul the piles into line, so that the sills and binders could be placed; and on several occasions, the spring of the piles, when released, has been sufficient to snap both sill and binder, and the process has had to be gone over again, and the binder strengthened by the bolting on of a long and heavy piece of oak.

It is easy to see what the effect of this, added to the inside pressure of the stone filling, would be, in case of accident to or rot in the sill of lower timber of the superstructure; and I have accordingly endeavored to provide in some measure against it by introducing iron-tie rods with heads, nuts, and washers at every ten feet of the structure and just below the water level.

In my last annual report I mentioned that "an entrance through this piling being once effected by the sea renders the *whole* structure insecure; but a similar entrance being effected in a pier, constructed as ordinarily with cribs, hurts that crib only which it has entered, and which may be entirely replaced without affecting the stability or safety of the remaining cribs." I may add, that while with such an injury to the pile pier immediate repairs would be necessary to prevent greater extension of the damage—repairs which it would not always be possible to make immediately—a similar injury to a crib construction might be allowed to run for some time without endangering the remainder of the pier.

To avoid this danger as much as possible, I have had cross walls or bulkheads of piles, at intervals of thirty feet, put in that portion of the work constructed since last winter; which modification, I understand, has since been employed in some of the harbor works on Lake Michigan.

Lastly, the wash of the sea through the openings left by the natural taper of the piles, removes the sand from the inside and causes a settlement of the stone filling, which has to be replaced, adding materially to the cost of the pier; this, in the west pier at Cleveland, half of which was constructed when I took charge of it, and under General Cram's immediate supervision, amounts to four feet, the filling having settled below the level of the sills and binders. This might be remedied by riprapping or the use of brush; but perhaps it is better to let it settle, and then to refill it.

As to repairs of the piling, they must consist of outside patching, or the removal of the stone filling and inside patching, or the removal of the entire superstructure above the opening in order that the piles may be driven in place. Either of the former methods would give a very awkward appearance to the pier, and the latter would be very expensive.

I now approach the subject of cost, and as indisputable facts are especially necessary here, I am fortunate in being able to give them to you as furnished by General Cram's scheme of a pile pier for Cleveland Harbor, and his scheme of a crib construction for Grand River Harbor, both of which works were executed by the same contractors. The prices are taken from his Cleveland contracts for the pile pier entered into between the 6th and 15th days of October, 1866, inclusive, for iron, piles, labor, stone, and lumber; the quantities are taken from his plans and the bills.

As the superstructure is the same in both, its consideration is omitted; and as the cribs are usually thirty feet in length, I compare with the cost of one of these the cost of thirty feet of the pile pier, both being brought up to the water level. Any increase in the length of the crib will of course show a more favorable result for that mode of construction.

Cost of materials.

PILE PIER—SUBSTRUCTURE.

48 15-inch piles, at $3 92	$188 16
60 lineal feet, 6 by 12 inches, at 20 cents per lineal foot	12 00
60 lineal feet, 4 by 8 inches, at 10 cents per lineal foot	6 00
	206 16

PILE PIER.

12 iron bolts, with nuts, screws, heads, and washers, 9.76 pounds each, per bid, at 7 cents per pound, 117.12 pounds	8 19
	214 35

CRIB PIER—SUBSTRUCTURE.

	Lineal feet.		
24 pieces 30 feet by 12 by 12 inches	720	Supposing 12 feet depth.	
24 end pieces, 18 feet by 12 by 12 inches	432		
11 ties, 18 feet by 12 by 12 inches	198		
at 30 cents per lineal foot	1,350		$405 00

CRIB PIER.

16 joists, 18 feet by 8 by 12 inches, say, at 25 cents per lineal foot, as the 12 by 12 inches costs 30 cents, and the 6 by 12 inches, 20 cents; 288 feet at 25 cents	72 00
8 floor plank, 28 feet by 12 by 12 inches; 448 feet b. m., at $26 per M., b. m	11 64
102 1-inch square iron bolts, 32 inches long, 8½ pounds each = 867 pounds, at 4¾ cents per pound	41 18
2½ pounds 10*d* cut nails, say, at 4 cents per pound	10
	529 92

LABOR.		LABOR.	
Driving 48 piles, at $5 each	$240 00	Placing 1,350 lineal feet of 12-inch timber, at 12 cents per lineal foot	$162 00
Placing 120 lineal feet of sill and binder, at 16 cents per lineal foot of each	19 20	Placing 2,304 feet, b. m., joist, at $8 per M., b. m.	18 43
	473 55	Placing 448 feet, b. m., floor plank, at $8 per M., b. m.	3 58
			713 93
PILE PIER.		**CRIB PIER.**	
30 feet by 16 by 12 inches = 45 cords, at $12 50 per cord, stone filling	562 50	28 feet by 16 feet by 10 feet 10 inches, = 37.9 cords of stone filling, at $12 50 per cord....	473 75
	1,036 05		1,187 68

which is a reduction of $151 below the cost of the crib construction, or about 12½ per cent., instead of 33, as was claimed in the report of 1866.

But to this we must add the cost of the extra stone required to remedy the settling of the original filling, which amounts to—

30 feet by 16 feet by 4 feet = 15 cords, at $12 50 per cord.....	$187 50		
	1,223 55		$1,187 68

an actual increase of $36 *over* the cost of the crib construction, or $1 20 per lineal foot; and if we add still the cost of a row of cross piles at every thirty feet, and the cost of the iron tie rods at every ten feet, both of which are essential to the security of the pier, we have—

Brought forward	$1,223 55	Brought forward.........	$1,187 68
12 piles, at $8 92, for cost and labor	107 04		
3 iron ties, say, at $5 each......	15 00		
	1,345 59		1,187 68

a difference of $158 in favor of the crib work, a reduction of about twelve per cent. on the cost of the pile pier, or $5 30 per lineal foot.

It will be remembered that the above is a comparison of *facts*—quantities that have been used, and prices that have been paid, under General Cram's contracts.

I will remark, in addition, that the prices for the piles are very much below the rates paid under contract at the other works of which I have relieved General Cram, while the price of timber is considerably above what it can now be had for.

The price which the contractors get for putting on the sills and binders, *i. e.*, sixteen cents per lineal foot, is most markedly inadequate, in view of the extraordinary exertions necessary to bring the piles into line; and no future contract could be made with them or with any one else knowing the difficulties to be encountered in the prosecution of this labor without a largely increased allowance therefor.

The conclusion to be deduced from these facts is inevitable: the *close pile pier* is an expensive blunder not to be sanctioned, except in shoal water with clay bottom, and when through the fluctuations of the lumber market the cost of the piling may chance to fall below the cost of a crib construction.

Of the appropriation for the improvement of this harbor, approved June 23, 1866, there was an available balance July 1, 1867, of	$30,858 99
Allotted from the general appropriation of July 25, 1868, for the repair, preservation, extension, and completion of certain public works, or rivers and harbors	17,000 00
Allotted from the general appropriation of 1869 for the improvement of rivers and harbors, for the fiscal year ending June 30, 1869, and the year ending June 30, 1870, $9,000; afterward increased to	12,000 00
	59,858 99
There has been received and expended during the year ending June 30, 1869, the sum of	39,427 05
Balance June 30, 1869	20,431 94

all of which will be expended by the close of September, the work completed, and the appropriations and allotments exhausted.

Required, according to previous estimates, to make the harbor available for vessels of fourteen feet draught, the sum of $39,000; all of which could profitably be expended within the next fiscal year.

It is probable that small appropriations will occasionally be required to repair the loss of stone and injury to the piers, probably not less than $1,000 per year.

The large number of tugs and steamers passing in and out of this harbor seem to exercise a beneficial influence in keeping down the bar.

This harbor is situated in the collection district of Cuyahoga, and is a port of entry. The absence of information concerning its revenues for the past year is explained in my report upon Conneaut Harbor. There was collected here from customs during the preceding year ending June 30, 1868, the sum of—

In currency	$30,022 59
In coin	53,970 62
	83,993 21

which is the only index the collector furnished in respect to the amount of commerce likely to be benefited by the completion of the improvement.

D 9.

Report of operations in the improvement of Grand River Harbor, Ohio, for the year ending June 30, 1869.

The east pier extension, of which four cribs had been sunk at the close of last year's operations, has been completed by the sinking of six more, and the completion of their superstructure.

In view of the great settlement which had taken place in the exposed end cribs during the preceding winter, I deemed it advisable to riprap the last two cribs of the extension on both sides and at the end—the riprap extending inward from the extremity of the pier sixty feet, rising to within four feet of the surface of the water, and taking its natural slope.

The work was then carefully leveled, and again after the subsidence of the spring freshets, when it was found that the settlement was only from two to four inches, instead of from six to eight feet as in the preceding winter—furnishing a sufficiently strong justification of the means employed to accomplish this end.

In order to ascertain the effect which the extension of the east pier had had in deepening the channel, I caused to be made in May a careful examination of its depth, the soundings being taken with a graduated pole at every ten feet of lines of soundings twenty feet apart. The effect is well shown by the sketch hereto appended.

As was to be expected the deep water of the river has extended itself to the end of the pier, and the sand thus displaced has been carried further out and deposited. In other words, the bar has been moved out bodily just about as much as the pier has been extended—the water having shoaled in many places from three to four feet.

At the same time the old bar has been cut away in many places to the same extent, and as its material has been deposited in deeper water, the new bar has not risen high enough to obstruct the passage of vessels which could get over the old bar as it is, and there has been an absolute improvement in depth of channel of about 2.29 feet. For at the stage of water indicated by the sketch herewith, ten feet could be carried in without difficulty now, when, at the time of General Cram's survey, 7.5 feet + .314 foot = 7.81 feet, was all that he claimed could enter; the plane of reference being the same for both, which is the same as that of the survey of this harbor made in August, 1865, by William J. Casquain, under orders of Colonel William F. Raynolds, aide-de-camp and major of engineers.

The past winter on the lakes has been a very mild one, and the spring freshets consequently were very light, otherwise there would have been a still more marked effect visible.

It will be observed that the deep water between the parallel portions of the piers has approached nearer to the western pier.

As to what had better yet be done to improve this harbor I am scarcely determined. The extension of the west pier in a direction parallel to the east pier, starting from the angle of flare, would undoubtedly force the bank which the sketch shows lies east of, and near to, its proposed position, further out, and what is now deep water would be shoaled, as has occurred in the case of the east pier extension.

The cost of 200 feet of pier extension would not be less in this deep sand than sixty dollars per lineal foot = $12,000.

The cost of removing 10,900 cubic yards of sand by dredging, which is the amount estimated on the basis of giving twelve feet depth across the bar and for the width of the channel-way between the piers, at fifty cents per cubic yard = $5,450.

It will be recollected that much or most of this sand, which has been twice driven further out into the lake, got into the channel originally through breaches in the west pier, and it is a question whether we shall not eventually be compelled to remove this artificially.

The whole subject, however, is one on which I hardly am prepared to make a decided recommendation, and concerning which I desire to procure further information.

The cost this year of extending the east pier has been $10,777 37.

By Engineer Department letter of June 24, 1868, there was available for the prosecution of the work at Grand River, Ohio, $74,072, independently of any balance remaining in the hands of General Cram.

By General Cram's report for 1867, it is stated that of the appropri-

ations for this harbor, there was available June 30, 1867, $81,310 22, of which he had expended before I relieved him $8,128 10, leaving available $73,182 12, which amounts are so near alike as to afford presumptive evidence reciprocally of correctness.

But, by the reports of the Chief of Engineers for 1866 and 1867, it is stated that the balance available for this harbor was, July 1, 1867, $53,310 22; which I assume as correct, although there is nothing in my possession to show how this difference of $28,000 could have arisen.

Balance July 1, 1867		$53,310 22
Expended by General Cram, 1867	$8,128 10	
From general appropriation of 1864	493 40	
Special appropriation of 1867	7,634 70	
Expended by me, 1868	93 12	
		7,727 82
Balance July 1, 1868		45,582 40
Expended during the past year		10,777 37
Available June 30, 1869		34,805 03

for application to pier extension, or dredging, and the further improvement of this harbor.

No further appropriation is needed, and no further operations are contemplated immediately.

Grand River Harbor is in the collection district of Cuyahoga, port of Fairport.

The amount of customs collected here in the fiscal year ending June 30, 1868, was—

In currency	$53 25
In coin	638 75
	692 00

For the reasons stated in my report on Conneaut Harbor, the statistics required for the past year are not given.

D 10.

Report of operations in improving the harbor at Ashtabula, Ohio, for the year ending June 30, 1869.

At the close of last year's operations, eight cribs had been sunk in the east pier extension; by November of that year, four more had been sunk on that side, and eight in the west pier extension, their superstructures put on, and the whole work completed. Here, as at Conneaut, the tops of the piles used in the corners of the cribs were left projecting at intervals above the deck plank, constituting snubbing posts; in all cases these posts being on the side of the pier farthest from the channel.

Careful levelings were taken here after the close of operations in the fall, and again in the spring, when it appeared that both extensions had settled from two inches to two feet, somewhat irregularly, but with a general descent toward their outer extremities.

As there are but a few feet of sand here over a shale substratum, it is not likely that any further settlement will take place.

All that remains to be done now, in order to complete the improvement of this harbor as proposed by General Cram, is the deepening of the channel to twelve feet, which will require the removal of a large quantity of sand and shale rock. Proposals for doing this work were called for by advertisement in May, resulting in June in the letting of the job to Renseler R. Dodge, of Fulton, New York, at thirty cents per cubic yard for sand, and one dollar and twenty cents for rock dredging. Abstracts of bids are rendered herewith.

Operations, however, were not commenced here until August, when the dredges employed gave satisfactory evidence of their ability to accomplish the difficult work which they are employed to do. About 4,400 cubic yards of sand and rock were removed by the simple power of the dredge, without blasting or cutting, up to the end of August. Two dredges are now on, and it is probable that the greater part or the whole of the undertaking will be accomplished by the close of navigation this fall. This is very satisfactory, in view of the doubt which dredgemen felt, generally, as to the practicability of doing this work without blasting, in consequence of which, previous bids had run so high as absolutely to forbid us from contracting for the work.

There has been expended in the completion of the pier extensions the sum of	$28,412 94
Balance on hand June 30, 1868	48,310 16
Balance June 30, 1869	19,897 22

which, under our present contract, will be sufficient for completing the dredging of this harbor without the additional appropriation called for in the last annual report.

This will complete the improvement of this harbor, leaving nothing more to be done than the repair of the old wood work as it becomes decayed. It remains to be seen whether the outflow of this river from a channel between equal and parallel piers will be sufficient to prevent the formation of a bar off its mouth. Another season will probably give us the means of deciding this.

Ashtabula Harbor is in the collection district of Cuyahoga, and my inability to furnish satisfactory information concerning the amount of commerce likely to be benefited by its improvement is explained by the remarks on this head in my report on Conneaut Harbor.

During the year preceding this, upon which I am reporting, there was collected from customs at the port of Ashtabula $90 70 in currency, and $3 63 in gold. The commerce of the lake seems to be generally better this year than it was last year, and it is probable that better results would be shown by the custom-house records if we could get at them.

The Lake Shore railroad has a branch already graded from the coal fields to Ashtabula Harbor, and in the event of its completion this will probably become a coal port of considerable importance.

Abstract of bids received for dredging Ashtabula Harbor, Ohio, to accompany annual report for the year ending June 30, 1869.

Name of bidder.	5,000 cubic yards of sand, more or less, to be removed from the bed of the channel.	6,000 cubic yards of soft shale rock, more or less, to be removed from the bed of the channel.
Lee & Dunbar, of Erie, Pa	Fifty cents per cubic yard	\$4 50 per cubic yard.
Renseler R. Dodge, of Fulton, N. Y	Thirty cents per cubic yard	\$1 20 per cubic yard.

And a contract was accordingly authorized and made with Renseler R. Dodge in accordance with his bid.

WALTER McFARLAND,
Major of Engineers.

D 11.

Report of operations in the improvement of Conneaut Harbor, Ohio, for the year ending June 30, 1869.

The breach behind the east pier, mentioned in my last annual report, was rebuilt last fall. It was found necessary in filling this opening, which was reported as one hundred and fifty feet in length, to make use of a structure one hundred and eighty feet in length, in order to secure a connection with a ridge rising several feet above the general level of the river bottom. There is no reason now to apprehend any further breaking through behind this pier where the river is swollen through freshets.

All the cribs of the west pier extension were sunk in place. Owing to a sudden storm which arose before the first two could be secured by stone filling, these two were carried away and had to be replaced by new ones, the additional expense of which was borne by the recent allotment of nine thousand dollars for the repair of the breach behind the east pier.

This completes the work prescribed for the improvement of this harbor, excepting the dredging, which still remains to be done.

After much consideration of the subject, knowing the aversion that has heretofore existed to the introduction of snubbing posts in these piers, I have thought it best to make use of them for two reasons; first, because where they do not exist the piers have to suffer through the tearing up of the deck plank, in order that vessel men may reach the joists, to which they tie up, and the injury thus resulting (for this occurs at *every* pier where there are no snubbing posts) is much greater than can result from the introduction of such posts when firmly placed; and, second, because in freezing weather it often becomes a question of life and death whether a vessel can hold fast to the pier. I have therefore introduced them in the west pier extension, or rather, I have omitted cutting off the tops of the piles which are driven in the outer corners of the cribs, thus furnishing good snubbing posts at every thirty feet, driven into the bottom, and with the entire width of the pier between them and the vessels which may tie up to them.

The amount received and expended in these operations during the fiscal year ending June 30, 1869, was \$14,213 74; allotted April 10, 1869, from the general appropriation for that year, \$9,000; which, since the 30th of June, has been entirely expended, and the work of pier extension and repairs in this harbor completed.

The work still remaining to be done, of dredging the channel, approved

September 12, 1866, will not amount to more than $6,000; which still is to be appropriated.

It will be observed that in my last annual report it was stated that there was still needed to complete the work of improvement at this harbor the sum of $22,000; of which there has been supplied by allotment $9,000, and yet I now report that but $6,000 more is needed to complete the work, showing that the former estimate was too large by 7,000. This arose from the fact that General Cram's estimate for the west pier extension, which I incorporated in my last annual report, was for a pier three hundred and fifty feet long, while the depth of water, twelve feet, which that was designed to reach, was actually attained by a pier only two hundred and forty feet long, costing a little over $7,000, or less than that estimated for.

The west pier extension having been made this spring, its effect upon the channel is not yet observable. It is probable that a small amount of dredging may periodically be required here, if it be determined to maintain twelve feet depth of channel, though the little commerce which the place has, and its comparative uselessness as a harbor of refuge lead me to doubt whether that will be necessary.

Conneaut Harbor is situated in the collection district of Cuyahoga, and is a port of entry. No answer has yet been received as to the amount of revenue collected here, and the amount of tonnage likely to be benefited by the completion. Collector Watmough, of Cleveland, is unable to give me this information, for the reason that the books containing it have been removed from the Cleveland custom-house by the former collector, Mr. Grannis, and although my letter of inquiry was referred to this gentleman no answer is yet received. Last year there was so much delay in answering my inquiries concerning these matters that my annual report was sent off before the desired information reached me, and I shall therefore give you that information here, which will probably serve sufficiently the purpose desired.

In the year ending June 30, 1868, there was collected for duties at Conneaut Harbor $18 in currency, which Deputy Collector Phil. Kessler, at Cleveland, thinks indicates the amount of commerce likely to be benefited by the improvements in progress.

D 12.

Report of operations in the improvement of Erie Harbor, Pennsylvania, for the year ending June 30, 1869.

The operations in progress at this harbor at the close of the last fiscal year, ending June 30, 1868, were the repair of the damaged north pier and the dredging of the inner bar; and those contemplated were the completion of these items and the repair of the breakwater extending from the south pier to the south shore of the bay.

The repair of three quarters (380 feet) of the damaged north pier was completed in September, and this part was strongly riprapped. The remaining one hundred and twenty feet, being too badly damaged to be worth repair, it was deemed advisable to leave it for the storms of winter to loosen, preparatory to removing it entirely and replacing it by a new construction. From careful levels taken after the close of operations in the fall and again after the opening of navigation in the spring, it is found that the riprap has answered its purpose perfectly, no settlement whatever of the pier which it was designed to protect being perceptible. The remaining wrecked portion of this pier will be removed

during the present season, and replaced by a construction of the same general character, riprapped as is the repaired portion.

A part of the old north pier also is becoming dilapidated, and will require repairing during the present season.

The channel across the inner bar has been dredged to the depth of thirteen feet below the ordinary low-water stage, and for a width of one hundred feet. During the present season it will be widened to two hundred feet, and deepened another foot, which will give a little over thirteen feet depth at the lowest stage of water in the fall months. A lump on the outer bar, apparently caused by the motion of a heavily-laden vessel which had grounded there, was also cut away. In these operations over twenty-seven thousand cubic yards of sand were removed.

Nothing has been done toward rebuilding the breakwater connecting the south pier with the south shore, because doubts were entertained as to the necessity or expediency of spending money here. I have decided, however, that it will be prudent to repair it to the water level, it being useless, I believe, in its sheltered position in shoal water, to carry it any higher, and, with the consent of the department, that work will be begun, if not completed, this fall.

The estimate of $35,000 for dredging the channel over the inner bar, contained in my last annual report, was made for a channel three hundred feet wide and thirteen feet deep, below the stage of water to which was referred the soundings on the chart of Erie Harbor, made in 1865 and 1866

It was discovered in November last, but too late for insertion in the annual report, that this stage of water was at least a foot above the ordinary low-water stage of the fall months, and that consequently, in order to secure thirteen feet depth of water at all seasons, it would be necessary to dredge a foot or more deeper than had been contemplated; at a probable cost, for a channel three hundred feet wide, of $30,750. As it was by all means desirable to secure the required depth, it was decided to make the channel for the present but two hundred feet wide, my estimate being large enough to pay for thirteen feet depth at lowest water for this reduced width. In order, therefore, to make this channel of the width recommended by me in my last annual report, this additional amount of $30,750 would be needed. The present width, however, seems to be highly satisfactory to navigators, although I think it still advisable to give the additional hundred feet of width originally recommended.

By my last annual report, there was needed to complete the repairs of the north pier and the improvement of the channels, in addition to the appropriations and allotments previously made, the sum of	$3,650 00
For rebuilding breakwater and other repairs	34,000 00
	37,650 00
Of which there has been allotted from the general "appropriation for the improvement of rivers and harbors for the year ending June 30, 1869"	22,500 00
Leaving	15,150 00
still to be appropriated for the accomplishment of these especial objects; to which must be added, if the channel is to be widened to three hundred feet, with its present depth of thirteen feet below low-water stage	30,750 00
Total to be appropriated	45,900 00

If it be decided, however, that the present channel is sufficiently wide, this amount will be ample for carrying out the project mentioned in the letter of the Chief of Engineers to the Hon. Secretary of War, dated Engineer Department, Washington, February 19, 1867, for giving to this harbor, among others, a depth of fifteen feet at the lowest stage known; and thirty thousand dollars more would be required to give this depth over a width of three hundred feet; these estimates being based upon the present rate of dredging at this harbor, which is thirty-seven and a half cents per cubic yard.

The amount expended in the prosecution of these labors during the past year is $21,173 76, which includes several payments for retained percentage and advertising due at the time that the charge of the improvement of this harbor devolved upon me.

Still available, June 30, of the allotment of $40,000, of which I was notified July 30, 1868	$33,500 00
Allotment from the appropriation approved April 10, 1869	22,500 00
Available June 30, 1869	56,000 00

all of which will probably be expended by the close of navigation this fall.

The completion of the repairs upon the north pier and the breakwater connecting the south pier and the south shore of the bay, and the deepening and widening of the channel across the inner bar, will complete the improvement of this admirable harbor.

There will always be more or less deterioration of the wooden piers, and a gradual re-formation of the outer bar, which will need to be remedied by dredging. I presume that a thousand dollars a year will be more than sufficient to keep both in good order.

There is a degree of satisfaction amongst sailors and shipping men concerning the present condition of the harbor, that is very agreeable to witness. The heaviest laden vessels go in and out without difficulty, and nothing goes aground unless it runs out of the channel, which is exceedingly well marked, and with reasonable care need never be missed by day or night.

It is not easy to say what amount of commerce is likely to be benefited by the completion of the improvements in progress. Erie is rapidly awakening from the lethargy which for years has bound it, and bids fair to hold the first place in the coal and iron trade of the lakes.

During the past year a revenue of $20,670 has been collected from customs, which is nearly double what was collected during the preceding year. The number of vessels which have entered and cleared during the same period is 2,364, with an aggregate tonnage of 776,298 tons, an increase over last year of twelve per cent. in the number of vessels and forty per cent. in the amount of tonnage. While the average tonnage of the vessels which entered and departed last year was 267 tons, the average tonnage of those which entered and departed this year is 328, an increase in average tonnage of twenty-three per cent.

Collector Gaggin, in furnishing me with the information above given, adds: "In connection with this report I would state that the important improvements lately made in the channels of this harbor have very largely increased the commerce of the port; and not only in an augmented trade, but in the heavier draught of vessels now able to do business here."

It is certain that the navigators all along the lake where I have been, speak with unmixed satisfaction of the condition of Erie harbor.

This harbor is in the collection district of Erie, and Erie is a port of entry.

The entire amount of the estimate for the completion of the improvements here may be profitably expended within the next year.

No contracts concerning it have been entered into since the date of my last annual report.

Two dredges are kept at work in the improvement of the inner channel, night and day, with the expectation of finishing that work by December first of the present year, and it is expected that the repairs mentioned as necessary in an earlier part of this report will be completed at the same time.

APPENDIX E.

UNITED STATES ENGINEER OFFICE,
Buffalo, September 13, 1869.

GENERAL: I have the honor to submit the following annual report of the progress made in the work of harbor improvement in my charge for the fiscal year ending June 30, 1869:

BUFFALO HARBOR.

I.—*History and condition of the work during the year.*

Operations for the fiscal year began with a vigorous prosecution of the work of interior harbor improvement, in the order directed in instructions from the Chief of Engineers dated April 3, 1868, as follows:

Repair and protection of existing piers.—The south United States pier was repaired throughout its whole extent, the masonry of the lower or harbor section protected by a row of piling confined by sill and binder work and sheathed to low-water level, and the pier-head was built up and backed with stone according to the plans transferred to me by my predecessor in charge. The completion of this work was delayed until the close of the working season, on account of its connection with the pier extension, likewise retarded from causes hereafter stated. Just subsequent to its being completed and closed, a severe storm arose which damaged the pier-head somewhat, but not to any great extent, by loss of stone, planking, and joists, and developed the necessity of re-enforcement at this point as well as repair. By letters from the Chief of Engineers dated January 6 and April 19, 1869, I was authorized to take the necessary measures for the protection of this part of the work, but as the gale which did the damage also coated the pier-head with ice, nothing could be done until the opening of navigation in 1869. The work was taken up as soon as possible, but owing to its particularly exposed location, has constantly been delayed by the extraordinarily unfavorable working season of the present year. At the close of the fiscal year the work was nearly completed.

The repair of the north United States pier has only been undertaken occasionally, when it was too stormy to employ a force outside. The ruin of the old pier head has been dredged out; a new pier head built and protected by piling, sill and binder work, and sheathing similar to that used to protect the masonry of the south United States piers, harbor section. The new pier head was nearly completed at the close of the fiscal year. Nothing was done toward repairing the stonework of

the pier, owing to the necessity of using it as a ground for the storage and framing of timber for outer harbor work.

Extension of the south pier.—The south United States pier was extended on the line of prolongation of its harbor section for a distance of three hundred and eighteen feet, measured from the axis of the light-house. This work was greatly retarded by the difficulties of the site, (yielding sand continually shifting under the action of a cross current,) and by the repeated collisions of inward-bound vessels with the unfinished work. Early in the season it was found necessary to greatly re-enforce my predecessor's plans of crib building, especially by introducing more iron in the construction, and, notably, screw and washer bolts in the three lower crib courses. Settling in the cribs was also constant throughout the whole working season, necessitating an extra outlay of labor and material, much in excess of the original estimate. These circumstances will account for the corresponding excess of expenditure upon this portion of the harbor improvement. The work was finally completed only after constant building up of the cribs as they settled, and when the nature of the site had been practically changed from sand to stone, by the constant settling of the crib filling through the grillage intervals of the crib bottoms. The westerly or pier-head crib of the extension settled bodily on its original site, into the sand at least seven feet in the course of the season, besides sifting out through its grillage bottom about half its stone filling. A like action to a lesser extent took place throughout the whole extension. It may therefore now be considered as firmly anchored.

Dredging between the south pier extension, and course of north pier prolonged.—This dredging I have postponed until work on the south pier shall have permanently closed.

Construction of breakwater.—Preparations for this work had been made during the year, and material for it began to arrive in the fall and winter of 1868, and is still being supplied. Framing was carried on during the late fall and winter in anticipation of starting the work upon the ice. The winter was so mild, however, that no ice formed of sufficient thickness to venture to work upon it, excepting at one time when, the ground having been resurveyed and the position of the first crib to be sunk located, a sudden thaw necessitated the speedy withdrawal of material from the site, just as the crib bottom had commenced to be put together. It is true that in the early spring a few bitter cold days again increased the thickness of the ice so that it could be worked upon, but from the lateness of the season and the warning previously received of the unreliability of the weather, it was considered imprudent to again risk the men and material. Nothing, therefore, could be done until the opening of navigation in 1869. This was extraordinarily late in occurring and the season very unfavorable for working, but by dint of energetic prosecution of the work at every favorable occasion, the laying and filling of these cribs (one hundred and fifty feet) had been effected at the closing of the fiscal year.

II.—*Steps taken for prosecution of work during present working season, and probable progress.*

What remains to be done of interior harbor work will probably be finished this working season under existing contracts and special authorities. About eight hundred feet of breakwater can be built under existing contracts, and it was expected to finish this by the close of the working season, but the work has already been greatly delayed by continuous stormy weather. Should the weather continue as unfavorable as

heretofore throughout the season, the completion of the present contract will be prolonged into the winter or possibly delayed until next spring.

On May 5, 1869, I received notification of a special allotment of $90,000 from "appropriation for the improvement of rivers and harbors, for the fiscal year ending June 30, 1869," "and the year ending June 30, 1870," to be applied to the improvement of Buffalo Harbor. This I propose to devote mainly to the pushing forward of the breakwater, reserving only a small amount for such repairs as may become necessary upon the interior works. I am instructed to apply this money "by contract or otherwise as may in my judgment best subserve the interest of the government, or prove to be most economical." Inasmuch as the work done by the present contractors, Messrs. Bailey & Denney, has been eminently satisfactory, and the material supplied by them of the best quality; as they have the requisite machinery and equipments on hand for the construction of the work, which other parties or the United States would have to supply or purchase from them, I have considered it expedient to invite of them a tender for continuing the supply of labor and material for the work, under the $90,000 allotment, from the conclusion of their present contracts. Should the terms they offer prove just and reasonable, and cheaper than I could undertake the work, by purchasing machinery, hiring labor, and purchasing material in open market, I propose to contract with them for the continuance of the work, allowing them to follow it up from the point they leave off under their existing contracts. It is probable that they will be able to come to terms as to every item, excepting that perhaps of iron material, which Buffalo iron firms may perhaps be able to supply cheaper, and as good as they can procure it.

From 1,000 to 1,200 feet breakwater will probably be built from funds at present available.

Sections 2 *and* 3, *circular June* 10, 1868.—The data required by these sections is herewith respectfully submitted. In estimates for funds I still include the project of opening the south channel from Lake Erie into Buffalo Creek, for the relief of the interior harbor and up-stream commerce. For details of the plan of operations I propose at this point I respectfully refer to a memoir dated November 21, 1868, and submitted to the Chief of Engineers shortly after. Some of the contingencies therein referred to have already occurred. Preparations have already been made by a private corporation to blast out a channel, and build wharves along the creek front for a distance of about one-fourth of a mile above the Ohio street toll bridge. Dredging and blasting to the extent of $100,000 is already under contract and commenced. When these improvements shall have been effected the necessity of a south channel will become still more apparent than at present.

BUFFALO SEA WALL.

This work remains in same condition as stated in my last annual report, and, for reasons therein given, further work upon it is not recommended at present.

DUNKIRK HARBOR.

I. *History and condition of the work during the year.*

At the close of the last fiscal year, 454 running feet of this work had been built in accordance with the plans turned over to me by my predecessor in charge. Its construction was continued during the working

season, and it was expected to have completed it by the 1st of November, 1868. On the nights of the 7th and 8th of October, 1868, all the under-water work having been completed and partly built over, a severe gale arose, which breached the pier to the extent of 210 feet, carrying away seven cribs with the few courses of superstructure which had been built over them.

On the 10th of October, 1868, I made a full report to the Chief of Engineers of the disaster, and on the 29th of the same month submitted a project for repair and re-enforcement of the pier, embodying fundamental changes in the manner of crib construction. This project was approved, and I was subsequently directed to advertise for proposals for the work, which was done, and the work let on 16th February, 1869.

In the meanwhile, the season had so far advanced that nothing more could be done to the work until the spring of 1869. The wreck was accordingly cleared away, and the work secured for the winter.

Upon the opening of the working season of 1869, the re-enforcement of the work was commenced, and at the close of the fiscal year four buttress cribs, 120 feet under-water work, had been put in position and filled with stone, and two more were ready for sinking.

Construction of new breakwater.—In accordance with instructions from the Chief of Engineers, proposals were advertised for, for the construction of so much of this work as could be built out of the balance of appropriation available for that purpose. On the 10th of September, 1868, the work was let, labor upon it to commence in the spring of 1869. At the beginning of the working season the construction was begun, and at the close of the fiscal year seven cribs (210 running feet) of the breakwater had been laid, filled with stone, and partly built over with superstructure; the framing of two more cribs for the work was progressing at the same time.

Removal of old outer breakwater.—The necessity for this operation was set forth in my last annual report, and sanctioned by the Chief of Engineers by letter of August 1, 1868. The work was accordingly advertised, and let on the 10th of September, 1868, the removal to be effected during the working season of 1869. At the close of the fiscal year the work had not been yet attempted, the necessary machinery not having arrived.

II. *Steps taken for prosecution of work during present working season, and probable progress.*

Notwithstanding the unfavorable working season, and the continual drawbacks repeatedly experienced by reason of stormy weather, it is hoped that the repair and re-enforcement of the west United States pier, the removal of the old outer breakwater, and the construction of the section of new breakwater now under contract, will all have been effected by the close of the present working season. It is possible, however, that the completion of one or both of the building operations may necessarily, on account of the weather, be postponed until next spring. The removal of the old outer breakwater will, however, be effected shortly, unless the contractors fail in their contract. The completion of the above-mentioned operations will absorb the balance on hand of the existing appropriation excepting a small reserve for repairs.

The recommendations contained in my last annual report, as to additional improvements in this harbor, are respectfully renewed, especially the completion of the breakwater, now fairly in process of construction.

Data to accompany annual report of harbor improvement, for the fiscal year ending June 30, 1869, *in compliance with provisions of sections* 2 *and* 3 *of circular from headquarters Corps of Engineers, June* 10, 1868.

Amount required for the entire completion of each work:

Buffalo Harbor:	Completion of interior harbor work	$14,000 00
	Completion of breakwater	637,803 17
	Construction of south channel	225,000 00
Total		876,803 17
Buffalo sea wall		$50,000 00
Dunkirk Harbor:	Completion of west United States pier	$15,338 11
	Completion of breakwater	135,376 58
	Dredging old breakwater	2,179 41
	Dredging and blasting in harbor	255,000 00
Total		407,894 10

Amount that can be profitably expended upon each work during the next fiscal year:

Buffalo Harbor	$206,762 19
Buffalo sea wall	000,000 00
Dunkirk Harbor	72,681 24

Collection district in which each work is located:

Buffalo Harbor and sea wall, in the district of Buffalo Creek, New York.

Dunkirk Harbor, in the district of Dunkirk, New York.

At or near what port of entry, light-house, or fort, each work is located:

Buffalo Harbor and sea wall are near Fort Porter, New York. Light-house on south pier. Beacon on middle reef.

Dunkirk Harbor has light-house on main land. Beacon at end of west pier.

Amount of revenue collected at the nearest port of entry for the last fiscal year:

Collection district of Buffalo Creek, New York	$479,138 97
Collection district of Dunkirk, New York	5,281 73

Amount of commerce or navigation which would be benefited by completion of each particular work:

Buffalo Harbor.

Name of work.	Entrances and clearances.	Tonnage.
Buffalo Harbor, New York	11,333	4,293,220
Dunkirk Harbor, New York	281	68,856.75

ABSTRACT OF PROPOSALS ATTACHED.

Abstract of contracts for each class of materials or labor for each work, with names of contractors.

Name of work.	Name of contractor and what he contracts for.
Buffalo Harbor, New York.....	J. E. & D. E. Bailey, of Toledo, Ohio, and Alonzo D. Denny, of Detroit, Michigan, for all material and labor.
Buffalo sea wall................	Not under contract.
Dunkirk Harbor	Hart & Jennings, of Fulton, New York, for all labor, and also for timber and lumber for breakwater. Bailey & Denny, of Buffalo, New York, for all material for repair of west pier. Pratt & Co., of Buffalo, New York, for all iron material for breakwater.

Statement of cash received and expended on account of each work during fiscal year, and amount of appropriation available June 30, 1869, *and amount required for the year ending June* 30, 1871.

	Amount received.	Amount expended.	Amount available June 30, 1869.	Amount required for year ending June 30, 1871.
Improving harbor of Buffalo, New York................	$119,124 82	$105,865 12	$177,259 70	$220,000 00
Improving harbor of Dunkirk, New York.............	60,166 55	48,985 31	42,681 24	100,000 00

No repairs will probably be required on any of the works for the next three years. After that time $1,000 per annum for each harbor may be required to keep the piers and breakwater in repair. The channel dredging at Buffalo Harbor is done annually by the city authorities.

Respectfully submitted.

F. HARWOOD,
Captain Engineers and Brevet Lieutenant Colonel U. S. A.

Brevet Major General A. A. HUMPHREYS,
Brigadier General and Chief of Engineers,
Office of the Chief of Engineers, Washington, D. C.

NOTE.—Sketches to accompany this report will be forwarded on roll.

Abstract of bids received and opened February 16, 1869, for repair and re-enforcement of the west United States pier at Dunkirk, New York.

Number.	Name and residence of bidder.	Class A. Furnishing and delivering all timber and lumber, 337,592 feet.	Class B. Furnishing and delivering all iron materials— Item I. Drift bolt iron, 13,166.72 lbs.	Class B. Item II. Head, nut, screw, and washer bolts, 6,545.53 lbs.	Class B. Item III. Spikes, 4,616.55 lbs.	Class B. Total amount of bid for all iron.	Class C. Performing labor— Item I. All under-water work timber, 20,426 feet.	Class C. Item II. Superstructure, 6,950 feet.	Class C. Item III. Furnishing and putting in the work, all stone, 816 cords.	Class C. Item IV. Fitting, gaining in, &c., all joists and plank, scantling and boards, 71,092 feet.	Total amount of bids for all class C.	Total amount of repairs, &c., as per these bids.
		Per m. ft. b. m.	*Per lb.*	*Per lb.*	*Per lb.*		*Per lin. ft.*	*Per lin. ft.*	*Per cord.*	*Per m. ft. b. m.*		
1	Pratt & Company, Buffalo, New York		$0 3¾	$0 6	$0 6	$1,163 54						
2	Edwin H. French, Fulton, New York	$20 00	5	7	6½	1,416 67	$0 12	$0 10	$7 00	$9 00	$9,697 94	
3	R. Nelson Gere, Syracuse, New York*	38 00‡ 34 00§ 22 00‖	4.48	6.8	5.8	1,302 80	20	12½	14 00	8 00	17,196 68	
4	Charles L. Degraw, Fulton, New York	17 40	7	7	7	1,703 10	9	10	7 00	9 00	9,085 16	
5	Kemiesh McKenzie, Ashtabula, Ohio	19 00	4½	9½	7	1,570 49	10	8½	9 00	8 00	10,716 08	
6	Wilder & Howe, Corry, Pennsylvania†	15 00‖ 28 00§										
7	Hart & Jennings, Fulton, New York	17 00	6	6	6	1,459 80	8	10	6 55	5 00	8,229 34	
8	A. D. Denney & D. E. Bailey, Buffalo, New York	16 48	3¾	6	5	1,117 37	10	10	7 00	7 00	9,147 24	
9	Alexander McDonell, Hamilton, Ont	17 00	4½	7	7½	1,397 00	12	10	5 50	15 00	8,900 50	
10	Charles M. Hemmenway, Buffalo, New York	16 85	3¾	6	5	1,117 37	12	8	7 95	6 75	10,134 19	
	Bailey & Denny, (lumber)											$5,563 51
	Bailey & Denny, (iron)											1,117 37
	Hart & Jennings, (labor)											8,229 34
	Total											14,910 22

* Irregular. † Irregular; no guarantor; no duplicate. ‡ Oak. § Pine. ‖ Hemlock.

Abstract of bids received and opened September 10, 1868,

No.	Name and residence of bidder.	DIVISION I. — REMOVING THE OLD OUTER BREAKWATER. — CLASS A. — Case 1. — Item 1. — Removing stone to depth of 14 feet below U. S. standard, low water.	Case 1. — Item 2. — Removing old timber to depth of 14 feet below U. S. standard, low water.	Case 1. — Item 3. — Delivering in harbor stone removed in item 1.	Case 1. — Item 4. — Delivering in harbor timber removed in item 2.	Case 2. — Item 1. — Leveling stone to depth of 14 feet below U. S. standard, low water.	Case 2. — Item 2. — Leveling timber to depth of 14 feet below U. S. standard, low water.
		Per cord.	*Cents per lin. ft.*	*Per cord.*	*Per cord.*	*Per cord.*	*C'ts per lin. ft.*
1	Pratt & Co., Buffalo, N. Y.	....	....	....	....	....	....
2	R. Nelson Gere, Syracuse, N. Y.	$9 50	7½	$5 00	$5 00	$9 00	7½
3	J. T. Hayden, Buffalo, N. Y.	19 40	15	0 50	0 70	19 70	15½
4	Wilder & Howe, Corry, Pa.	....	....	....	....	....	....
5	Palmer & McDonald, Cleveland, Ohio.	....	....	....	....	....	....
6	P. Smith, Cleveland, Ohio	13 00	50	5 00	3 00	10 00	40
7	Alex. McCall, Walsh P. O., Ontario.	....	....	....	....	....	....
8	Ralph B. Day, Dunkirk, N. Y.	....	....	....	....	....	....
9	C. L. Degraw, Fulton, N. Y.	8 00	12	1 00	3 00	5 00	8
10	Denny & Parsons, Buffalo, N. Y.	10 00	12	9 00	10 00	10 00	12
11	F. B. Gallagher, Buffalo, N. Y.	7 75	12	3 00	4 00	6 50	9
12	Alex. McDonell, Hamilton, Ontario.	8 75	35	3 00	2 75	8 75	35
13	C. M. Hemmenway, Painesville, O.	9 00	10	9 00	10 00	9 00	10
14	L. F. Blair, Madison, O.	10 00	12	8 75	20 00	10 00	12
15	Lee & Dunbar, Erie, Pa.	20 00	20	4 00	6 c. per lin. foot.	20 00	20
16	Martin & Rhodes, Olean, N. Y.	9 50	50	2 50	2 50	10 00	100
17	T. J. Skidmore, Fredonia, N. Y.	....	....	....	....	....	....
18	George W. Talcott, Buffalo, N. Y.	8 75	8¾	8 75	8 75	8 75	8¾
19	L. A. Treat, Cleveland, O.	....	....	....	....	....	....
20	Hart & Jennings, Fulton, N. Y.	5 00	6	2 00	2 00	3 00	3
21	George M. Case, Fulton, N. Y.	6 00	8	4 00	4 00	9 00	8

* White pine.

† Hemlock.

‡ Irregular; no duplicate; no bondsmen.

§ Irregular; no duplicate; no bondsmen.

for improving harbor of Dunkirk, New York.

DIVISION II.								
CONSTRUCTION OF NEW BREAKWATER.								
CLASS A.	CLASS B. Furnishing and delivering iron.			CLASS C. Labor.				Remarks.
Item 1.	Item 1.	Item 2.	Item 3.	Item 1.	Item 2.	Item 3.	Item 4.	
Furnishing and delivering all timber and lumber.	Drift-bolt iron.	Screw and washer bolts.	Spikes.	All under-water work—timber.	Superstructure.	Furnishing and putting in the work—stone.	Framing, spiking, putting in, &c., all joists, scantling, planks and boards.	
Per M ft. b. m.	*Cents per lb.*	*Cents per lb.*	*Cents per lb.*	*Cents per lin. ft.*	*Cents per lin. ft.*	*Per cord.*	*Per M ft. b. m.*	
....	3¾	6	....	....	....	....	....	No duplicate.
$28 00	4½	6½	61.5	9	8½	$8 50	$9 00	All, or any.
55 00	15	22	13	36	42	21 00	30 00	Do.
30 00*	....	....	....	....	....	....	....	
18 50†	....	....	....	....	....	....	....	
28 00	5	7	6	....	....	14 00	..........†	
20 00	5	10	7	20	14	10 00	13 00‡	
17 95	....	....	....	....	....	....	....	
18 95	....	....	....	....	....	....	....	
20 00	5	9	8	10	10	8 00	5 00	
17 98	3⅞	7¾	5⅜	8¾	8¾	8 98	8 00	
19 00	4½	7	8	12	9	8 25	8 00	All, or none.
18 00	4¾	12	9	9	8	7 50	14 00	
17 75	3¾	8	5½	8	8	8 50	9 00	
17 95	3⅞	7½	5½	8½	8½	8¾ c'ts.pr. lin. ft.	8 00	Irregular.
....	....	....	....	....	....	....	....	Do.
18 00	6	9	9	20	9	9 00	7 00§	
18 50	4	6½	7½	14	14	7 90	10 00‖	
19 23	6¾	6¾	6¾	11½	11½	6 32	6 90	All, or any.
24 00	....	....	....	....	....	....	..........¶	
17 00	5	7	6	10	8	5 95	4 00	All, or any.
20 00	8	8	8	9	8	7 00	6 00	

‖ No duplicate; all, or none.

¶ No duplicate; all, or none.

** All, or any; no duplicate.

†† By telegraph; no bondsmen.

E 1.

UNITED STATES ENGINEER OFFICE,
Buffalo, New York, October 10, 1868.

GENERAL: I have the honor to report that the west pier at Dunkirk, New York, was breached by the gale of the nights of October 7 and 8, involving the partial loss of seven cribs, with so much of the superstructure as was built over them; in all 210 running feet of the work. At the time of the occurrence of the accident the pier was nearly finished, and it was expected to close the work at the end of the present month.

All the cribs were down and filled, and the superstructure almost completed, and had nearly all its ballast in.

The portion over the cribs carried away was about two-thirds filled. The accompanying Sketch, No. 1, will give an idea of the condition of the work.

The seven cribs, having parted at the joint between the bottom course and the one next above, have lost all their stone and are now hanging by the bond of the superstructure.

The foreman, who was on the ground at the time the breach commenced to make, reports that, as well as he could observe, it started shoreward and made gradually toward the beacon light. Crib No. 21 was first observed to careen slightly, and the others, between it and the beacon, followed in succession, when, after some time, the work parted at the joint of cribs No. 27 and 28, leaving the latter and crib No 29 intact. The work then assumed its present state, as shown on Sketch No. 1.

The following data and statements are respectfully submitted in justice to myself as engineer in charge, and in order to enable headquarters to form a judgment of the cause of the disaster.

Every one of the cribs parted at the joint of the bottom course and the one above it, wrenching out the bolts and leaving the bottoms on their original site.

Two of the bottom timbers came ashore, with most of the blocks (*a, a;* see Sketch No. 2) broken off; leaving the timber with essentially a cross-section 6 by 12 inches.

Sketch No. 2 shows in elevation the construction of the cribs, which is as designed by Brevet Major General T. J. Cram, United States Army, colonel corps of engineers, and carried into execution under his directions up to the time of my relieving him in charge of the work; excepting the oblique direction of the drift bolts, which I changed from the vertical upon taking charge, in accordance with his views expressed just prior to that event.

With that exception the construction has been carried on throughout the entire length of the pier so far as cribs No. 28 and 29, strictly in accordance with the plans and specifications turned over to me by him on my relieving him in charge of the work in June last.

Cribs Nos. 28 and 29 I planned to avoid the obvious weakness of having a re-entering at the beacon light, and in planning I took the liberty of changing the construction entirely, as the shape of the cribs had to be changed.

Those cribs stand undamaged as before the gale.

I have the honor to submit the following general plan for the repair and strengthening of the pier, which I will present in a maturer state, with estimates, as soon as they can be prepared.

In the first place, having made personal inspection of the wreck, I

am of the opinion that all the crib frames can be saved and used again in the work, although the superstructure and stone must be a clear loss.

I proposed to cut away the superstructure, float the crib frames ashore, draw them up on the beach, and upon such of them as are found in good condition to place a bottom of construction as indicated in Sketches Nos. 3 and 4, then launch them again, turn them over, and relay them and build over.

That will restore the pier, but I do not consider it by any means secured by these measures, as I am confident that future gales would again breach it shoreward from the repaired part. In order to prevent this, I propose to lay a line of buttress cribs, of construction and dimensions as indicated in Sketches Nos. 3 and 4, on the lake side of the main line of cribs, and breaking joints with them, building a superstructure upon them three timbers above water, bolt to the main superstructure, and deck over. This, I think, will insure the permanency of the work, by protecting the weak lower courses of the cribs now remaining in line. If headquarters should approve this plan, I respectfully request authority to enter into contract with the lowest responsible bidders on the new Dunkirk work, in order to be able to obtain screw bolts required in my plans. (Abstract of bids sent to headquarters with my letter of 15th September.) I have also to request that headquarters will furnish me as soon as possible with its instructions, as I have ordered the work to be left in *statu quo* until those instructions reach me.

In conclusion, I have to exonerate the contractor and his men, and the inspector, from any blame on account of this disaster. That their work was well executed is shown, by the fact that the seven crib frames are still hanging by the superstructure, and that at several points there are one foot square timbers snapped in two, the bolts still holding.

I respectfully submit the case with this report to headquarters, with the request that, if consistent with the good of the service, a board of officers may be ordered to inquire into the cause of the disaster, and fix my responsibility in connexion therewith.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Captain Engineers, Brevet Lieutenant Colonel U. S. A.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers.

E 2.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., October 29, 1868.

GENERAL: I have the honor to submit the following project for the repair and reinforcement of the west United States pier at Dunkirk, New York, accompanied by drawings and a schedule of relative expense.

A fuller examination of the wrecked cribs made in calm weather, and at a low stage of water, has developed the fact that their frames are not in a condition to be repaired to advantage. The racking due to gales which have occurred before they could be rescued, has crushed the dovetails of one or more ties in each crib, and parted the joints to such an extent as to render the frames useless as such. Much of the timber and iron from them can, however, be saved, in a condition for further use in the repair and reinforcing of the pier. The extra expense

necessarily incurred in clearing away the wreck and saving the material will, according to my present estimates, be about canceled by the value of the material saved, leaving a small balance, perhaps, in favor of the United States, not large enough, however, to be considered in computation of the whole cost of repairs. A strictly accurate estimate on this point cannot be made until the inspector's report is received.

By reference to the inclosed schedule it will be seen that the difference in cost of a crib on the plan of Brevet Major General T. J. Cram, United States Army, colonel corps of engineers, and one on mine, of the same size, is $10 86 in favor of General Cram's plan. In view, however, of the disaster of the 7th and 8th October, I do not consider his construction sufficienty strong; and, although I am confidant that cribs 18 feet wide, constructed on the plan herewith submitted, will not be wrecked in the heaviest sea, yet I am not sure that its force might not move the cribs bodily to leeward and twist the pier out of line. Cribs Nos. 28 and 29, built on somewhat the same plan as the one I propose, although they withstood the gale which wrecked seven in their vicinity, were twisted bodily, about a vertical axis, through a horizontal distance of two inches in arc, jamming the ends of the side timber on the lee side against the beacon-crib and making a corresponding gap to windward. If this effect is observed in oblique cribs, of an average width of 24 feet, what might be expected of cribs 18 feet wide exposed to the sea breaking directly against them? Not that I attribute this wrecking entirely to the force of the sea; for had not the pier given way the force would not have been applied at that point in that manner. But is there not danger that a force which, assisted by the leverage of the seven wrecked cribs, could move bodily such a mass as cribs No. 28 and 29, might, directly applied, shift the position of cribs only 18 feet wide.

The harbor of Dunkirk is so situated on Lake Erie, and has such a wide entrance, that, as a general rule, no matter in what direction the wind blows, unless it be off shore, the resulting seas, either entering directly or thrown out of course on entering the bight made by the west United States pier and light house point, are urged along in accumulating masses and finally thrown squarely against the pier. Thus the effect of a gale from the westward, the seas from which roll along the south coast of Lake Erie and make around the light-house point, are nearly identical in effect with the gales from the northwest, which blow directly into the harbor and deliver the resulting seas squarely against the pier; and gales from the northeast, piling the water up in the bight, produce an accumulation of water, accompanied by a chopping sea, which eventually results in a like effect as that above stated.

Headquarters has prescribed a width of 20 feet to the break-water about to be built. I consider the west pier as much, if not more, exposed than that work will be. The crib north of the pier is to stand in an average of 7 feet soundings, the break-water in an average of 8.5 feet. But, on the other hand, the pier starting from shore has only at one end an outlet for the accumulating mass of water pressing against it, while the break-water will be relieved at both ends and to a much greater extent; I therefore do not consider it prudent to give the pier a less width than 20 feet. Were it not for motives of economy I should recommend 24 feet width for both works, in order to be on the safe side as to stability. I am of opinion, however, that a work at this locality 20 feet in width well and carefully constructed and with a continuous and well bonded superstructure will stand any ordinary gale.

The difference between the cost of a crib 18 feet wide and 20 feet wide

is $67 69, and in the whole project, on account of difference in width of cribs, $905 80.

The necessity of re-enforcing on the lake side the remaining cribs of the same construction as those which broke loose from their bottoms is evident. So much of the pier as is bolted to the old work I consider secure. The remainder, begining at crib No. 4, I propose to re-enforce by laying buttress cribs to break joints with the original ones

The plan indicated in the drawing is respectfully submitted, the only question being as to the width of cribs. A crib 8 feet in width is the minimum I can recommend, inasmuch as the average depth of water along their site is 6 feet, and a crib 8 feet wide, of 1 foot square timbers, would only give a cross section in stone of 6 feet square. The outer cribs, which stand in about 8 feet water, would have in stone their base less than their altitude, which I do not consider advisable. I therefore recommend a width of 10 feet to these cribs which will make them stable in all contingencies.

Difference in cost of 8 feet wide and 10 feet wide, buttress crib, $40 96, and in the whole project, on account of this difference, $984 43.

Over these buttress cribs I propose to lay one course of superstructure, bolt to the main work, fill and deck over.

TO COMPLETE THE PIER HEAD.

Just before I was placed in charge of the work General Cram changed the direction of the pier (which was then running with its lake face bearing on the most lakeward front of the beacon crib) in such a manner that the shore face should run bearing on the shore end of the beacon crib, the result of which would be to make a re-entering at the pier head exposed to the incoming seas. I did not concur in this change, but it having been effected on my taking charge, I considered it more expedient to follow the course thus taken than to change again, making a concavity to lakeward in the remaining course of the pier. I then proceeded to remedy what I considered the resulting weak point in the construction, by putting in at the pier head the oblique cribs Nos. 28 and 29.

Now by shifting to lakeward the seven cribs, necessary to fill the gap, where the wrecked section stood, so as to lay these cribs on the line of the buttress cribs, I will not only be able to give the work a more uniform appearance in plan and migitate in a meausre the patched appearance due to the buttress cribs, but will also very nearly get back on the old line, so that the line of lake face of all the cribs will run nearly on the lakeward point of the beacon crib, which I consider much stronger than the course heretofore pursued. To complete this effect, and finish up the pier head, the additional buttress cribs, *b* 19, *b* 20, become necessary.

Additional expense thus entailed, $1,746 57.

The order in which I propose to take up the work is first to re-enforce, then to repair, then to complete the pier head.

I have already taken measures to secure for the winter the portion of pier still remaining, but there is yet a danger of a severe gale breaking up still more of the cribs of the old construction. Until they are re-enforced, my only security against this is the relief afforded by the gap in the pier where the breach was made. Whenever a gale occurs the water rushes through this gap in great volume, thus relieving the rest of the pier. Hence the order of the work I recommend.

RECAPITULATION.

Project No. 1.—To re-enforce with 18 feet buttress cribs, 30 feet long and 8 feet wide; to repair with 7 cribs 30 feet long and 18 feet wide, laid on the old line, and complete the pier head on the old plan. Total cost, $16,542 37.

Upon this I report adversely, as I am not confident that the cribs are sufficiently wide, and I am opposed to the old line, on account of the re-entering at the pier head, only partially remedied by cribs Nos. 28 and 29, and because this project leaves the buttress cribs exterior to the whole work.

Project No. 2.—To re-enforce with 17 buttress cribs 30 feet long and 8 feet wide, and one 15 feet long and 8 feet wide; to repair with 7 cribs 30 feet long and 18 feet wide, laid on line of buttress cribs, and complete pier head with addition of cribs *b* 19 and *b* 20. Total cost, $18,033 61.

I am in favor of this, excepting as to the width of cribs, which I consider insufficient.

Project No. 3.—Same as No. 2, excepting to make buttress cribs 10 feet wide and cribs for repairs 20 feet wide. Total cost, $19,923 84; which last project is respectfully recommended for adoption.

In calculating the extra expenditure from the appropriation necessitated by the carrying out of either of these projects, there is to be deducted the cost of so much of the work remaining to be done on the wrecked section at the time of its carrying away. This amounts to $2,335 48, which being deducted from each of the above, leaves for total additional expenditure for—

Project No. 1	$14,206 89
Add 10 per cent. for contingencies	1,420 68
Total	15,627 57
Project No. 2	$15,698 13
Add 10 per cent. for contingencies	1,569 81
Total	17,267 94
Project No. 3	$17,588 36
Add 10 per cent. for contingencies	1,758 83
Total	19,347 19

N. B.—A comparison between the value of the material saved, as reported by the inspector, and the expense incurred in removing the wreck, shows about $100 in favor of the United States.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Captain Engineers, Brevet Lieutenant Colonel U. S. A.

Major General A. A. HUMPHREYS,
Chief of Engineers, Headquarters
Corps of Engineers, Washington, D. C.

Schedule of comparative expense for the repair and re-enforcement of the west United States pier at Dunkirk, New York.

Damage done by gale of October 7 and 8, 1868:

In cribs	$5,041 68
In superstructure	1,944 45
Total damage	6,986 13

RELATIVE COST OF CRIBS.

N. B.—All cribs to be 30 feet in length.

For repair.

Old style, 18 feet wide	$720 24
New style, 18 feet wide	731 10
New style, 20 feet wide	798 79

Total in cribs for repairs.

Old style, 18 feet wide, 7 cribs	$5,041 68
New style, 18 feet wide, 7 cribs. (Projects 1 and 2)	5,117 70
New style, 20 feet wide, 7 cribs. (Project 3)	5,591 53

For re-enforcement.

Buttress crib, 8 feet wide	$326 93
Buttress crib, 10 feet wide	367 89

Total in cribs for re-enforcement.

Buttress cribs, 8 feet wide, 18 such. (Project No. 1)	$5,884 74
Buttress cribs, 8 feet wide, 17½ such. (Project No. 2)	5,679 47
Buttress cribs, 10 feet wide, 17½ such. (Project No. 3)	6,396 27
Buttress cribs, *b*19 and *b*20, at pier head. (Project Nos. 2 and 3)	1,242 02

RELATIVE COST OF SUPERSTRUCTURE.

For repair.

To 6 feet in height, over 7 cribs 18 feet wide. (Project Nos. 1 and 2)	$3,036 27
To 6 feet in height, over 7 cribs 20 feet wide. (Project No. 3)	3,468 24

For re-enforcement.

To 1 foot in height, over 18 buttress cribs 8 feet wide. (Project No. 1)	$1,260 00
To 1 foot in height, over 17½ buttress cribs 8 feet wide. (Project No. 2)	1,209 94
To 1 foot in height, over 17½ buttress cribs 10 feet wide. (Project No. 3)	1,477 57
To 6 feet in height, over *b*19 and *b*20. (Project Nos. 2 and 3)	504 55

TOTAL COST OF COMPLETION OF PIER HEAD.

Project No. 1, superstructure of cribs 28 and 29		$1,243 66
Project Nos. 2 and 3, which includes cribs *b*19 and *b*20 with superstructure over them, and cribs 28 and 29, which latter are already built, laid and paid for		2,990 23

TOTAL COST—PROJECT NO. 1.

For repair.		
In cribs	$5,117 70	
In superstructure	3,036 27	
		8,153 97
For re-enforcement.		
In cribs	5,884 74	
In superstructure	1,260 00	
		7,144 74
To complete pier head, superstructure over cribs No. 28 and 29		1,243 66
Total		16,542 37

PROJECT NO. 2.

For repair.		
In cribs and superstructure, being the same as in project No. 1		$8,153 97
For re-enforcement.		
In cribs	$5,679 47	
In superstructure	1,209 94	
		6,889 41
To complete pier head.		
Cribs *b*19 and *b*20, and superstructure over them, and cribs 28 and 29		2,990 23
Total		18,033 61

PROJECT NO. 3.

For repair.		
In cribs	$5,591 53	
In superstructure	3,468 24	
		$9,059 77
For re-enforcement.		
In cribs	6,396 27	
In superstructure	1,477 57	
		7,873 84
To complete pier head as in project No. 2		2,990 23
Total		19,923 84

From each of which projects deduct cost of work remaining to be done when the damage occurred, viz:

ALL IN SUPERSTRUCTURE.

Over the 7 cribs	$1,091 82	
Over cribs Nos. 28 and 29	1,243 66	
		$2,335 48

Leaving for the additional expenditure due to each project as follows:

Project No. 1	$16,542 37	
Deduct	2,335 48	
		$14,206 89
Add 10 per cent. for contingencies		1,420 68
		15,627 57
Project No. 2	$18,033 61	
Deduct	2,335 48	
		$15,698 13
Add 10 per cent. for contingencies		1,569 81
		17,267 94
Project No. 3	$19,923 84	
Deduct	2,335 48	
		$17,588 36
Add 10 per cent. for contingencies		1,758 83
		19,347 19

F. HARWOOD,
Captain Engineers and Brevet Lieutenant Colonel U. S. A.

E 3.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., November 10, 1868.

GENERAL: In my memoir of October 29, 1868, on the subject of the repair and reinforcement of the west United States pier at Dunkirk, N. Y., I propose to reinforce by buttress cribs on the lake side of the pier.

To explain the reason for this position which, unexplained, may appear somewhat anomalous, I have the honor to call the attention of headquarters to my report of October 10, 1868, on the manner in which the break occurred. It will be seen from that report that the wrecked cribs parted from their bottoms, wrenching the bolts out of the lower side courses, and breaking the blocks *a a* off from them, leaving the timbers essentially 6 inches by 12 inches in cross-section, whereas originally they were 1 foot 11.

In saving the wrecked cribs the fact has been developed that this action took place in every one of the wrecked cribs, save, perhaps, crib

No. 24—the only one which now remains in the position into which it was swung by the gale. It was also reported to me by eye-witnesses that the action was gradual, the cribs one after another careening townward. It thus appears that the parting of the lower courses began as would naturally be the case on the lake side. That side is therefore the one which particularlly needs protection, and therefore I propose to put the buttress cribs on that side to protect the weak lower courses from the direct action of the sea, to which they would otherwise be exposed.

Were the buttress cribs to be placed on the townward side it would be necessary, in my opinion, to build the superstructure of the buttress cribs squarely up to the level of the pier itself, which would greatly increase the cost of reinforcing; and even then, I do not think the combination would be as strong as the one already proposed, having buttress cribs on the lake side with only one course of superstructure, because in a heavy gale, the defective lower courses of the main pier being directly exposed to the action of the sea, the least settling townward of the buttress cribs, they being on the townward side, would render possible the opening of the lower lake side courses of the main work, as in the gale of October 7th and 8th; and this action once begun, if to the extent of allowing the flat slate filling to be sucked out by the rifling through the opened seam, would of course eventually result in at least a serious damage to the work, if not a complete wreck. I therefore cling to the opinion that the buttress cribs in this case should be on the lake side.

I am not apprehensive of any great settling of the buttress cribs to lakeward from the pier, should they be placed on the lake side, which action might be expected in ordinary cases, for the reason that the solid rock is found at no place on the line of the pier at a greater distance than two feet from the natural bottom of the lake. This is shown by the fact that the stone has settled through the grillage of the cribs built with open bottoms not more than 18 inches in any place, and no crib frame has settled more than eight inches. The slight careening lakeward of the buttress cribs which might possibly occur at some points, due to even this slight settling, can be remedied by allowing those cribs to stand until fully settled, then level up and pack any apertures which may occur between the buttress cribs and main pier, and fit the course of superstructure over the top crib timber and packing in such a manner as to make a tight joint.

I am of opinion that such precaution being taken, there could be no danger of any further parting of the buttress from the pier.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Captain Engineers, Brevet Lieutenant Colonel U. S. A.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Headquarters
Corps Engineers, Washington, D. C.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., November 12, 1868.

COLONEL: Your letter of the 10th instant, giving your reason for reinforcing the west United States pier at Dunkirk on the lake side, &c., has been received.

Your explanation is satisfactory, and you are authorized to repair and

reinforce the pier referred to in accordance with the plan and recommendations submitted in your letters of October 10th and 29th, 1868.

Very respectfully, your obedient servant,

JNO. G. PARKE,
Major of Engineers, Brevet Major General.

By command of Brig. Gen. Humphreys.

Capt. and Brevet Lt. Col. F. HARWOOD,
Corps of Engineers, Buffalo, N. Y.

E 4.

UNITED STATES ENGINEER OFFICE,
Buffalo, N. Y., November 20, 1868.

GENERAL: By headquarters instructions of October 16, 1868, I am required to prepare and submit sketches showing the projected improvements of the harbors under my charge.

The project of a south channel from Lake Erie into Buffalo Creek was a part of the general scheme brought to the consideration of the board of engineers, of January, 1867, on the improvement of Buffalo Harbor, and was by that board indorsed in the following terms: "The upper inlet or canal proposed to afford a direct entrance from the lake to the upper or southern portion of the inner harbor, (which is the Buffalo Creek,) thus giving an additional ingress and egress, is considered important to the inner harbor, and whenever it is made will add largely to the convenience of commerce."

The proceedings of that board having been approved by headquarters, it is understood that the projected south channel is to be accounted as one of the proposed improvements of Buffalo Harbor, and, therefore, to be marked on the sketch showing these improvements. But before so doing it is necessary to decide upon the general plan and course of the channel, which were not determined by the board, the matter having only received a general consideration and approval.

I therefore have indicated on the sketch a plan which I have projected after much thought and deliberation, and which I believe to combine to the greatest extent possible at this locality the elements of economy, durability, and accessibility, all three of which are very necessary to the success of a project which has never met with much favor in any quarter, although quite generally admitted to form a very desirable part of the general scheme of improvement. This plan is respectfully submitted as combining the best features of the previous plans, hereafter enumerated, and I am bold to assert that I am confident that it will effect the object of making a secure and accessible channel at a cost not disproportionate to the advantages to the commerce of the port which must necessarily result from its construction.

I append herewith a sketch which will give a comparative view of the most prominent schemes heretofore devised, together with the one which I have adopted from them all.

It is necessary to premise by stating that the site of these projects, as well as the one herewith submitted, is a little over a mile from the mouth of the creek, and the soil in which the excavation must be made is a stiff clay, overlain by about eight inches of sand.

Some years ago an attempt was made to construct a channel from

Lake Erie into the Blackwell Canal, which attempt proved a disastrous failure, and, as I think, simply because it was not made in the right manner and with the proper precautions. The site is indicated on the appended sketch, and all that remains to show it is the double row of piles there indicated. It appears that an excavation was actually made 100 feet wide, and to a depth of nearly 14 feet below water level, from Lake Erie to the Blackwell Canal, the lake being separated from the canal by a temporary dam. A gale arose which breached the dam and filled the cut with sand up to the general level of the beach, whereupon the enterprise was abandoned, and which disaster, I presume, contributes to a considerable extent to the general distrust of further projects of like nature at that point. From this disaster we learn, as a little forethought might have previously shown to the projectors of the work above referred to, that it is useless to attempt to make a channel from Lake Erie into Buffalo Creek without previously protecting effectually the Lake Erie entrance from the effects of gales, and this can only be done by first building the protecting piers which must at any rate eventually be constructed, being a very essential feature of the entire project.

It is, perhaps, as well that this project did fail, inasmuch as the cut was to have been made so nearly at right angles to the axis of the Blackwell Canal at the point of entrance, that it would have been almost impossible for vessels of such lengths as we have at present to have passed in or out.

The next project I find, which still retains this faulty position of the cut, proposes to defend the Lake Erie entrance by a pier running the same course as the south United States pier at the mouth of the creek, and extending into the lake to 20 feet soundings; also to mark the channel limit on the north side by a short pier of less width. This device, while effectual in protecting the Lake Erie entrance, at the same time, by reason of the abrupt turn it necessitates at that point, makes the entrance quite as impracticable as the exit at the other end due to the erroneous course of the channel which it still retained.

The direction of this pier is indicated on the sketch in dotted blue, although not its full length. I have made use of the idea to suggest a plan which might be used in case a great saving in the items of piering might be desirable, even at the expense of convenience of ingress and egress. A single pier, as indicated on the sketch, with the north limit of the channel defined and preserved by a close row of piles, would be the least expensive and yet effectual protection to the Lake Erie entrance. But, at the same time, the channel would be inconvenient of access to all vessels, and almost impracticable to those of great length. I therefore reject this plan, excepting as a last expedient, for the reason that I consider it important that a work of this nature should be so constructed as to meet the wants of commerce fully for all time, so far as we can judge of what those wants will be in the future.

I now pass to my own experience and researches as to the best direction and construction of this channel. Upon his assuming charge of the works of improvement of Buffalo Harbor, Brevet Major General T. J. Cram, colonel of engineers, directed me, among other duties assigned to me as his assistant at Buffalo, to make a careful examination and survey of the ground in the vicinity of the site of the old project for the south channel, and to select and submit to him a site which should fulfill the conditions of necessitating the minimum amount of excavation and yet have the axis of the proposed channel intersect that of Buffalo Creek at

an angle convenient for the passage to and fro of vessels of the greatest length now on the lakes.

This task was fulfilled in the fall of 1867, and the result submitted with a survey, the essential part of which is reproduced on the inclosed sketch. The ground within the blue lines was reported as fulfilling the prescribed conditions to the best advantage. Upon relieving General Cram in charge of the works at Buffalo in the spring of the present year, I received from him plans, specifications, and bills of materials for a proposed south channel based on my survey of last year.

The project indicated by his plans and specifications is shown in full blue lines, and to this project, after full consideration, I dissent, for reasons which I will proceed to set forth:

1st. As to the direction of the piers. This is not laid down on General Cram's drawing, but it is inferred from their lengths that they were intended to be placed as indicated in the appended sketch. Any other position not open to the objection I am about to make would be open to the one already made, of making the turn at the Lake Erie entrance too acute. Discussing, therefore, the direction of the piers as indicated in full blue, there is first to be borne in mind the object of piers at the Lake Erie entrance, viz: to prevent the choking up of that entrance by sand brought along by the littoral current and thrown shoreward by the seas resulting from westerly gales.

Will the direction of the piers S′ and N′ prevent this from taking place? I say no. At the first start there is no cause for apprehension, because the littoral current bringing down the sand in suspension will deposit it in the angle A. But when that angle is filled to the level of the beach, which will not be very long, (judging from what happened to the channel when it was destroyed,) and when the shore makes, as it will eventually, in a curve out to the very end of the south pier S′, how can the 14 feet of water be preserved at that point, and what is to prevent the channel from choking up, as in the case of the old one, on the first heavy gale after the beach reaches the pier-head? The direction of the heaviest seas, determined by personal observation on my part, is laid down on the sketch. A comparison of this direction with the course of the piers will illustrate my course of reasoning.

This course of reasoning led me to the conclusion that no system of parallel piers would answer in this locality, unless inclined to the northward of the general direction of heavy seas, which would make the objectionable abrupt turn at the lake entrance of the cut, and even then the south pier must be made much longer than the north one in order to force the bar, which must inevitably form at some time or other, to make at a sufficient distance from the north pier-head to admit of a channel remaining between that pier-head and the probable bar sufficient for vessels to pass until the bar could be dredged away. But this gives another sharp turn at the north pier-head, and taken altogether, a very inconvenient, indeed almost inaccessible channel.

I advance, therefore, the following propositions:

1st. That the littoral current holding the sand in suspension, would form either a beach or a shoal against the south pier, no matter what its course. 2d. That the beach or shoal when made would constitute a magazine, from which in gales of wind sufficient sand would be drawn in one gale to form a serious bar at the head of that pier. 3d. That in the case of the two parallel piers S′ and N′, this bar will almost, if not quite, fill the channel and render it inaccessible for a time until it shall have been removed, at a great expense sufficient, perhaps, to counterbalance the advantage of having a channel at this point, in which case

that channel would meet the fate of the old attempt before referred to. That disastrous project might, perhaps, be adduced as sufficient argument to condemn the project of two parallel piers only, as a defense to the Lake Erie entrance; but in order to elucidate the subject fully, I have to request attention to the appended sketch, on which I have indicated the probable bars, marked B.

Now I argue that these deposits will be comparatively trivial in all cases but one, and that the plan indicated in blue and its similar cases. In that case the waves having thrown the sand in suspension it will be borne along by the littoral current, and finding the cut as indicated in blue, with open arms ready to receive it, will be forced into that cut, and, I venture to say, but little sand will pass the cut until the gale subsides. This of course will necessitate a formidable amount of dredging after each gale, and in my opinion more than could be profitably done. In fact I think that the cut under such circumstances would have to be abandoned.

Therefore, after due thought and mature deliberation, I have projected the plan indicated in red, which is respectfully submitted as best combining the three essentials, economy, accessibility, and durability.

1. *Economy.*—On this score as well as that of accessibility I have selected the site of the old cut for the lake entrance. To carry it further to the southward would make the curve of entrance too abrupt, and bring us on no lower ground. To carry it further to the northward would bring us on higher ground and necessitate more excavation.

On the site of the old cut where I have located the entrance I gain an easy curve, and beside. the advantage of the old excavation, which is filled in with loose sand only, and lies almost entirely within my project, thus saving me just that much excavation in clay.

After leaving the Lake Erie entrance I take as nearly as possible the route of my survey of 1867, which follows the lowest ground. I incline slightly to the northward in order to avoid the limit of outcropping rock in Buffalo Creek, so as to get rid of the contingency of blasting.

For the rest on this point I have the honor to call attention to the comparative estimates herewith appended drawn between my plan and that indicated by General Cram's plan and specifications, by which it appears that my project is much the cheaper of the two.

2. *Accessibility.*—Beginning with the Lake Erie entrance I have to invite attention to sketch A, which shows the construction which I have adopted.

To avoid the difficulties heretofore discussed, I run out my parallel piers at right angles to the beach, which position is the most natural, gives the least amount of dredging between the piers, and forms the most effectual barrier to the sand borne along by the littoral current. I then run off from the south pier, at an angle to the direction of heavy seas, a prolongation S*s*, the end of which resting in about 20 feet water, shall be 500 feet from the north pier head and overlapped as to the course of heaviest seas nearly 200 feet. I thus give smooth water at the mouth of the cut, and allowing for the formation of the probable bar, will, according to my observations at the present mouth of the creek, even after the severest gale, have at least 350 feet channel between the bar and the north pier head. This bar will only form in the interval of time between the subsidence of the sea and the ultimate settling of the sand in suspension; for while the sea is up, striking against the pier prolongation S*s* it is deviated in a course opposed to the direction of the littoral current, and will drive the sand in suspension back to the edge of the shoal or beach, as the case may be, at the salient Q. It is only when the

force of the incoming sea has ceased to act, that the littoral current will again resume its course. Thus the very force, which in the project I have already objected to would tend to fill the cut with sand, I make use of to diminish the extent of the inevitable bar. Two hundred feet is the minimum width of a straight reach of channel for the proper accommodation of modern lake shipping. Where curves occur this width should be increased more or less, according to the greater or less degrees of curvature.

From the 350 feet wide entrance between the shoal and the north pier head the channel narrows down to 220 feet in the straight reach, the 20 feet over the 200 being necessary to allow 200 feet in the jaws of the channel at the junction with the beach. Thence I widen out toward Buffalo Creek in order to give 250 feet radius to the tangent curve at the next bend, which is about the minimum admissible for the accommodation of vessels of such lengths as we have at present on the lakes. From this curve I propose to narrow down again to 200 feet in width at the Buffalo Creek entrance. This course is respectfully submitted as the best as to accessibility that the circumstances of the case will allow, still having due regard to economy.

3. *Durability.*—As regards this, I place my principal dependence on the prolongations S*s*, which will defend the entrance from the inroads of the sand, and keep the channel serviceable. I propose to construct the prolongation of substantial crib work, varying in width from 20 feet at Q to 30 feet at the pier head. For the remainder of the channel, I propose to adopt the construction indicated by General Cram in his plans and specifications, excepting the pier N, which being in the case of my project entirely protected by the pier S, S*s*. I do not consider it necessary to give it a greater width than 12 feet, that of the canal diking. The mode of construction proposed by General Cram, while more economical than crib work, can be used to good advantage in the less exposed positions, being especially suited to the particular locality, the soil being, as before stated, a stiff clay overlaid by a thin stratum of sand not more than eight inches in thickness at any point. It has been urged in opposition to this channel that it could never be maintained even when constructed; that the dredging required to keep it open would be so great as to swallow up in its cost the advantages to be gained from having the channel. This might, indeed, be feared were the excavation all, or principally in sand or other loose soil. But, being principally in clay, we have nothing to fear excepting from the accumulation of the sand brought along by the littoral current, and this I claim to have fully provided for by interposing the pier prolongation S*s* at the Lake Erie entrance, which I expect to prevent the ingress of any of the Lake Erie sand further than the bar B.

The objection which has also been made, that the proposed cut would damage the shipping interests of the lower interior harbor, may also be answered in a similar way.

In fair weather there is no appreciable current in Buffalo Creek at the point where it is proposed to cut the channel, the water in it and Lake Erie standing practically at the same level. I therefore do not anticipate any current one way or the other in the channel after it is constructed, excepting when the water of Lake Erie or Buffalo Creek is disturbed by some extraneous cause. The principal disturbing cause in Lake Erie will be a westerly gale; in Buffalo Creek a freshet from the interior. Let us examine the effects by referring to those which now occur under like circumstances. Westerly gales pile up the water of Lake Erie against the Buffalo shore, flood the low land in the vicinity of the proposed channel, when the water subsiding passes off, back into the Lake,

some as it came, but a large volume is discharged through the medium of the channel of Buffalo Creek. The action of this water passing off, is of course somewhat the same as that of a freshet from the interior, and the two may be discussed together. In each case, of course, there results a deposit from the flood, made at different points in the lower interior harbor. In the one case the sand swept over from the lake by the flood; in the other the detritus brought down from the upper creek. But will this deposit be increased by the presence of the cut? I think not. There will be no current through it, as the action of the westerly gale will be as it is now, to back up the waters of Buffalo Creek wherever the water in Lake Erie in its rise meets the waters of the creek. The water forced through the cut meeting then with the water forced up the creek from its mouth, will be effectually stayed and the deposit, if any, will be in the cut itself or up the creek, but to no greater extent than would have occurred had not the cut been constructed, inasmuch as the only increment to the deposit which might result from the existence of the cut would be the sand of Lake Erie borne along by the littoral current, and sucked in by the current in the cut, which current I trust I have demonstrated will have no existence.

If this be admitted, all the objections as to damage of the lower harbor fall to the ground.

But on the other hand there is an effect on the cut itself of the downward current in Buffalo Creek, resulting from subsiding floods or freshets in the interior. The Buffalo Creek entrance of the cut being on the concave bank, the outsweeping current will probably strike full into it and deposit a formidable bar in the cut and Blackwell Canal. Should this be found to be the case, it will be necessary to construct a wing dam, D, to prevent it. Or a still better plan could be adopted, having in view the interests of the up-creek commerce, which will become of importance as soon as the channel is made. The cut as I have planned it, to accommodate the down-stream shipping, has its Buffalo Creek entrance of difficult access to vessels from up the creek, which are but few in number at present, principally barges from the iron works, &c., above. But should this shipping increase in number, as would probably be the case were the cut made, it might be accommodated by diverging the southern canal dike at C, and dispensing with the wing dam D, building an axial pier to the creek, starting from the Ohio Street Bridge and extending about 400 feet; leaving a channel of about 100 feet between it and the east bank, which is the one now used. This would render the cut accessible to up-stream shipping, and yet not render it liable to damage from the effect of freshets, for the pier P, would, I think, answer all the purposes of the wing dam D, and better too.

It will be impossible to prevent, entirely, the deposit of sediment in the cut during a freshet; but either the wing dam or pier would materially diminish the amount, by deflecting the current from the mouth of the cut, which current would carry the bulk of the sediment down the creek. There would still exist, of course, a current from creek to lake through the cut, due to the difference of level of the water in the creek and lake, but this, from the uniformly varied nature of the force, would have a uniformly varied velocity, and consequently deposit the sediment uniformly throughout the cut, excepting, perhaps, at the points $b + b'$, where small bars might be formed.

But I do not anticipate a sufficient deposit, even including the small bars, to necessitate more dredging than is required now, annually, at the mouth of the creek. If it should be objected that the position of the pier would narrow the channel too much, the answer is that it would simply define the channel as it now exists, the bottom of the creek being

rocky and shoaling toward the west bank, in the region between the proposed pier and that bank.

The entire project for a channel from Lake Erie into Buffalo Creek, according to the plan I have suggested, will, I estimate, cost about $200,000.

Twenty-five thousand dollars would be the probable additional amount required to build the pier P, or some other structure of like nature in the creek, for the accommodation of the up-stream shipping.

Whether the advantage resulting to the commerce of the lake, from the construction of the proposed channel, would not fully warrant the appropriation of the requisite amount for that purpose, is a question which, it appears to me, should receive due consideration when further appropriation is made for the benefit of this harbor.

I have been informed that it is designed by persons interested in this question to make the attempt to induce the next Congress to make a full and final appropriation for all the proposed harbor work at Buffalo. In that case, and should Congress see fit to consider the matter, it is as well that this project of a south channel should appear in a definite form, and I have to plead this as an excuse for now asking the attention of headquarters to a memoir on a subject which otherwise might appear too far in the future to warrant its consideration at the present moment.

The project is therefore submitted for the consideration of headquarters whenever the subject may demand attention.

I am, general, very respectfully, your obedient servant,

F. HARWOOD,
Captain of Engineers, Brevet Lieutenant Colonel U. S. A.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Headquarters
Corps of Engineers, Washington, D. C.

Comparative estimates of cost of construction of proposed south channel from Lake Erie into Buffalo Creek, at Buffalo, New York.

The following is the estimate based on plans and specifications of Brevet Major General T. J. Cram, United States Army, colonel Corps of Engineers:

210,773 cubic yards excavation, at 45 cents	$94,847 85
2,058 r. feet pile piering, 20 feet wide, at $50 30	103,517 40
2,170 r. feet canal diking, at $8 70	18,879 00
	217,244 25
Add 10 per cent. for contingencies	21,724 43
Total	238,968 68

The following is the estimate of cost of project of Brevet Lieutenant Colonel F. Harwood, United States Army, captain Corps of Engineers:

125,057 cubic yards excavation, at 45 cents	$56,275 65
970 r. feet pile piering, 20 feet wide, at $50 30	48,791 00
750 r. feet pile piering, 12 feet wide, at $42 79	32,092 50
420 r. feet crib work, at $71 68	30,105 60

2,020 r. feet canal diking, at $8 70	$17,574 00
	184,838 75
Add 10 per cent. for contingencies	18,483 87
Total	203,322 62

or, for the entire scheme, including improvements for accommodation of up-stream shipping and all other contingencies, $225,000.

Respectfully submitted.

F. HARWOOD,
Captain of Engineers and Brevet Lieutenant Colonel U. S. A.

APPENDIX F.

Annual report for the year ending June 30, 1869.—*Improvement of harbors on Lake Ontario and the St. Lawrence River.—In charge of Brevet Colonel C. E. Blunt, lieutenant colonel of engineers, until January* 1, 1869; *Brevet Brigadier General M. D. McAlester, major of engineers, until April* 23, 1869; *temporarily placed in charge of Brevet Lieutenant Colonel F. Harwood, captain of engineers, until May* 18, 1869; *since then in charge of Brevet Colonel Nicolas Bowen, major of engineers, assisted by Captain W. A. Jones and First Lieutenant B. D. Greene, Corps of Engineers.*

1. OGDENSBURG.

At the date of the last annual report, proposals had been invited for dredging in the Oswegatchie River below the bridge, and along the St. Lawrence front of the city, and upon the outer bar, north of the light-house, these being the points first named in the plan of permanent improvement submitted by the board of engineers, (Engineer Order No. 56, 11th May, 1868.)

A contract for this work was made with C. Daly in the fall of 1868, and the channel through the outer bar has since been completed.

A recent survey shows a clear channel at least twelve feet deep below low water, and averaging three hundred feet in width. No difficulty is experienced in entering the river. A small portion of the area to be dredged in the river below the bridge was removed last fall. The contractor is now engaged in dredging at this place, and will continue work until the available funds are exhausted.

The amount required in my estimation for the entire and permanent completion of the improvement of this harbor, according to the plan proposed by the board of engineers, in addition to the amount ($40,000) originally appropriated, is $175,000. Of this amount $100,000 is intended for the construction of the pile piers should they be needed. For dredging along the St. Lawrence River front, it is estimated that $75,000 will be needed. The whole amount can be used during the coming fiscal year, in case it is decided to continue the improvement.

Ogdensburg is a port of entry, with a light-house between Forts Ontario and Montgomery, one hundred and twenty miles from each. I have not yet received the commercial statistics of the place. This port is next in importance to Oswego; it is the terminus of the Northern railroad, the Rome and Watertown railroad, and the Northern Transportation Company's line of propellers.

The value of foreign imports during the year was	$1,228,273 46
Imports coastwise, no record kept.	
Exports coastwise and foreign	489,265 00
Number of arrivals	963
Tonnage of arrivals	244,826
Number of clearances	951
Tonnage of clearances	242,326
Amount available for this work July 1, 1868	37,118 58
Amount available July 1, 1869	19,272 49
Amount required for year ending June 30, 1871	175,000 00

Should the plan for improvement be carried out, it is supposed that a small annual expenditure only would be required to preserve its permanency. New lights would also be required.

Abstract of contract for improving harbor of Ogdensburg, New York, for the year ending June 30, 1869.

DREDGING.

Cornelius Daly, price per cubic yard	$1 45
Cornelius Daly, price per cubic yard	20

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel United States Army.

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2. OSWEGO.

Since the last annual report, the operations for the improvement of this harbor have been confined to dredging in the space inclosed by the United States pier, and repairing this pier. A great portion of one of the old "Franklin pier" cribs has been rebuilt, and the dredging required for the present at least has been completed.

It was proposed during the present season to prolong the pier in a northerly direction four hundred feet. Contracts for this extension were made by Brevet Brigadier General M. D. McAlester, major Corps of Engineers, in March. The death of General McAlester delayed the beginning of the work, and when I assumed charge in May, I found the contractor (for labor) unwilling to proceed with his contract. The work was re-advertised, but owing to the high rates bid for labor no contract was made.

In the meantime, to prevent delay, authority had been sent to prosecute the work by hired labor and purchase of materials. This extension will be completed this year; the old contracts for materials have been continued and are filling, and working parties are now forming.

The increasing demands of commerce at this point now demand the construction of a pier exterior to the present one. Until this is done, a uniform annual expenditure will be required for the repairs and preservation of the present pier, and as its condition is not good the expenditure of a large amount may be necessary.

It is thought that a balance will remain sufficient for the ordinary repairs of the pier this season.

Some changes having been made in the construction of cribs since the

last annual report, a tracing is herewith transmitted showing the method in practice at all the harbors under my charge; also showing the particular plan adopted for joining the new work with the old pier at Oswego.

I send herewith a sketch from a late survey showing a portion of Lake Ontario that I would propose to inclose for a new harbor. The direction of the pier and the space to be inclosed are only approximately fixed. The pier is in two wings, with a light-house crib 50 feet square in the middle of the entrance; the cribs to be 50 feet wide and built in the longest lengths practicable.

The estimated cost of the entire work is $2,500,000, of which amount $600,000 could be spent the first available season.

For the next fiscal year there will be required to complete repairs undertaken this season and make those that may become necessary, $35,000.

This amount will level up and refill all of the old pier, repair breaches in the old stone parapet, and put the work in good order.

Any appropriation made for the new pier should provide that the United States have supreme jurisdiction over all modifications contemplated within the harbor, along the shores or within the waters, and also have ceded to them a certain amount of land at either extremity of the proposed work. A new light-house would also be required.

Oswego is a port of entry, with Little and Big Sodus in its district. It has a light-house on the pier, and a Fort (Ontario) within its limits.

Duties collected for year	$1,014,170 20
Value of foreign imports	$5,349,557 00
Value of foreign exports	$1,192,919 00
Number of arrivals	4,457
Tonnage of arrivals	781,500
Number of clearances	4,518
Tonnage of clearances	782,381

Besides the above, the value of coastwise arrivals and clearances is very great.

This harbor is the most important on the lake, and is the seventh or eighth in importance in the country in amount of duties collected.

The Delaware, Lackawanna, and Western railroad, (connecting with the New York Central at Syracuse,) the Rome, Watertown, and Ogdensburg railroad, (connecting with the New York Central at Rome, and also with railroad to the eastern States and the Canadas, at Ogdensburg,) and the Syracuse and Oswego Canal, terminate at this point; besides, it is a landing for the Northern Transportation Company's propellers, and the Royal mail line of steamboats to Canada, stopping along the lake.

The principal commerce is in grain, breadstuffs, and lumber; it is expected that coal and railroad iron will be transferred here in largely increasing quantities.

With the extension of the new pier 400 feet to the north, (17° west,) a light-house should be placed at its extremity. Abstracts herewith:

Amount available for this work July 1, 1868	$49,823 92
Amount available for this work July 1, 1869	70,326 23
Amount required for year ending June 30, 1871, not including the $600,000	35,000 00

Abstract of proposals received and opened March 24, 1869, for improving the harbor of Oswego, New York, under the direction of the late Brevet Brigadier General M. D. McAlester, major of engineers.

Number.	Name of bidder.	Residence.	Class A.—Wrought-iron materials. Drift bolts.	Class A. Screw and washer bolts.	Class A. Spikes.	Class A. Total amount of bids for all of class A.	Class B.—Labor to be performed. Crib framing, (below water.)	Class B. Superstructure.	Class B. Stone.	Class B. Dredging.	Class B. Total amount of bids for all of class B.
			Per lb.	*Per lb.*	*Per lb.*		*Per c. ft.*	*Per c. ft.*	*Per cord.*	*Per c. yd.*	
1	R. Nelson Gere	Syracuse, N. Y	$0 5¼	$0 6⅜	$0 5⅞	$3,780 81	$0 6⅞	$0 6⅜	$8 90	$0 47	$19,150 26
2	J. W. P. Allen						10	10	8 00	90	20,007 40
3	Mead Belden	Syracuse, N. Y	5¼	9	6¼	4,461 27	5½	5	6 00	1 00	13,708 34
4	R. R. Dodge	Fulton, N. Y	4⅞	6¼	6¼	3,665 54	7	7½	6 00	1 00	14,881 83
5	Alex. McDonnell	Hamilton, Canada					11	9	6 75	4 00	19,516 63
6	Charles P. Morse	Oswego, N. Y					15	12	10 00	1 00	25,862 80
7	Edwin H. French	Fulton, N. Y					8	8	5 75	60	14,895 09
8	Hart & Jennings	do	8	8	8	5,637 81	8	8	6 00	1 00	15,479 44
9	Benj. F. Wells	do	4¼	7⅞	7¼	3,512 81	9⅝	7⅞	6 94	49	17,422 62
10	James Caldwell		5	8	7	3,934 54	10	8	5 90	49	15,916 06
11	Charles P. Kellogg	Oswego, N. Y	5⅛	6	5.9	3,946 18					
12	W. Clark, vice-president Shipman Spring and Axle Company.	Fort Plain, N. Y	10	11	7½	7,103 63					
13	Pratt & Co	Buffalo, N. Y	4⅛	6	5⅛	3,376 73					
14	John M. Horton	do	6⅛	6¼	6⅛	4,580 72					
15	Chas. F. Wadsworth, president Buffalo Union Iron Works.	do	6	8	6	4,468 36					
16	A. C. Powell	Syracuse, N. Y	6⅞	7⅝	6¾	4,931 81					
17	W. I. Hitchcock	Youngstown, Ohio	8⅛	11	5	6,201 09					

A true copy:

NICOLAS BOWEN,
Major Engineers and Brevet Colonel.

Abstracts of contracts for improving harbor of Oswego, New York, for the year ending June 30, 1869.

	W. M. Platt.	Pratt & Co.	James Caldwell.
12 by 12 inch pine timber, 30 feet long, per 1,000 feet b. m	$25 00	....	....
12 by 12 inch pine timber, 21 feet long, per 1,000 feet b. m	24 00	....	....
Pine plank, per 1,000 feet b. m	20 00	....	....
White-oak snubbing-posts per 1,000 feet b. m	24 00	....	....
Round wrought-iron drift bolts, per pound	....	$0 04½	....
Round wrought-iron screw and washer bolts, per pound	....	06	....
Wrought-iron spikes, per pound	....	05½	....
12 by 12 inch hemlock timber, 30 feet long, per 1,000 feet b. m	....	....	$17 00
12 by 12 inch hemlock timber, 21 feet long, per 1,000 feet b. m	....	....	16 00
Hemlock plank, per 1,000 feet b. m	....	....	15 00

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

Abstract of contract for improving harbor of Oswego, New York, for the year ending June 30, 1869.

Pratt & Co:

Round wrought-iron drift bolts, per pound	$0 04½
Round wrought-iron screw and washer bolts, per pound	06
Wrought-iron spikes, per pound	05½

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel United States Army.

Abstracts of contracts for improving harbor of Oswego, New York, for the year ending June 30, 1869.

Timber.	W. M. Platt.	James Caldwell.
12 by 12 inch pine timber, 30 feet long, per 1,000 feet b. m	$25 00	....
12 by 12 inch pine timber, 21 feet long, per 1,000 feet b. m	24 00	....
Pine plank, per 1,000 feet b. m	20 00	....
White-oak snubbing-posts, per 1,000 feet b. m	24 00	....
12 by 12 inch hemlock timber, 30 feet long, per 1,000 feet b. m	....	$17 00
12 by 12 inch hemlock timber, 21 feet long, per 1,000 feet b. m	....	16 00
Hemlock plank, per 1,000 feet b. m	....	15 00

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

3. LITTLE SODUS BAY.

The works at this point are not in a satisfactory condition. The superstructure was completed upon the three hundred feet of unfinished pier last season. The width of dredged channel was increased from eighty to two hundred feet. In the spring of this year it was found that the pier had sunken, in some places, several feet, and presented a bad appearance. This was probably due to dredging too near the face of the pier, and to the shifting sand of which the bottom is composed. Proposals have been received for the extension of the pier one hundred and fifty feet. This extension will be completed this year. This will exhaust the present appropriation. To complete the improvement as originally proposed, and necessary to make this a good harbor, (including dredging,) there will be needed an additional appropriation of $35,000. To restore the present pier to its proper shape, and to rebuild the breakwater, $25,000 will be required, and this amount is asked both for the preservation and appearance of the present construction.

This harbor is in the collection district of Oswego, which is the nearest port of entry, and where the nearest light-house and fort are situated. The statistics, which are insignificant, are included in those of Oswego. This, next to Big Sodus, is the best natural harbor in the lake, although, there being no light for the harbor, its entrance is not always practicable. Being only fifteen miles from Oswego, and having no commerce worth mentioning, (its fine natural advantages being its only recommendation,) all that is strictly required this coming year is the amount ($25,000) asked for to make the necessary repairs, and to dredge all that may be required to clear the channel. At present there is sufficient water—about 12 feet. The amounts asked for could be expended in one season.

Abstract of proposals and contracts herewith.

Amount available for this work July 1, 1868	$27, 860 51
Amount available for this work July 1, 1869	4, 017 39
Amount required for year ending June 30, 1871	25, 000 00

Abstract of proposals received and opened June 24, 1869, for improving harbor of Little Sodus, New York.

Number.	Name of bidder.	Residence.	CLASS I.—TIMBER.					CLASS II.—WROUGHT IRON MATERIALS.			CLASS III.—LABOR TO BE PERFORMED.					Remarks.
			Hemlock sticks, M ft. b. m.	Pine sticks, M ft. b. m.	Hemlock plank, M ft. b. m.	Pine plank, M ft. b. m.	Total amount of bids for all of class I.	Screw and washer bolts, per lb.	Drift bolts, per lb.	Total amount of bids for all of class II.	Dredging, cubic yard.	Framing, M ft. b. m.	Stone, cubic yard.	Bolting and spiking, per lb.	Total amount of bids for all of class III.	
1	E. H. French	Fulton, N. Y.	$30 75	$51 00	$35 00	$55 00	$2, 469 52					$12 50	$2 20			Irregular.
2	Chas. J. De Graw	do	30 00	50 00				$0 10	$0 10	$1, 200 00	$1 40	20 00	2 50			Do.
3	Joel B. Warner	do									1 00	12 00	2 00			Do.
4	R. R. Dodge	do	35 00								2 00	16 00	2 25			Do.
5	John King	Oswego, N. Y.						5¼	5¼	630 00						
6	S. B. Robinson	do									*100 00	8 25	1 69	$0 1	$4, 691 00	
7	C. P. Kellogg	do						5½	5½	660 00						

* For all.

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Bvt. Col. U. S. A.

Abstract of contract for improving harbor of Little Sodus, New York, for the year ending June 30, 1869.

S. B. Robinson:

Timber, per 1,000 feet, board measure	$8 25
Plank, per 1,000 feet, board measure	8 25

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

Abstract of contract for improving harbor of Little Sodus, New York, for year ending June 30, 1869.

		S. B. Robinson.	John King.
Iron	per pound..	$0 01	....
Spikes	do....	01	....
Round wrought-iron screw and washer bolts	do....	....	$0 05½
Round wrought-iron drift bolts	do....	....	05½

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Bvt. Col. U. S. A.

Abstract of contract for improving harbor of Little Sodus, New York, for the year ending June 30, 1869.

S. B. Robinson:

Stone, per cubic yard	$1 69

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

Abstract of contract for improving harbor of Little Sodus, New York, for the year ending June 30, 1869.

S. B. Robinson:

Removing material and preparing foundation area	$100 00

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

Abstract of contracts for improving harbor of Little Sodus, New York, for the year ending June 30, 1869.

	S. B. Robinson.	John King.
Removing materials and preparing foundation area	$100 00	....
Timber .... per 1,000 ft. b. m.	8 25	....
Plank .... do.	8 25	....
Iron .... per pound	01	....
Spikes .... do.	01	....
Stone .... per cubic yard	1 69	....
Round wrought-iron screw and washer bolts .... per pound	....	$0 05¼
Round wrought-iron drift bolts .... do.	....	05¼

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Bvt. Col. U. S. A.

4. BIG SODUS BAY.

The pier has been completed, with the exception of the light-house head—776 feet having been built since the last report, there being considerable timber on hand, which was only available for the extension of the pier; and as it appeared that benefit would be derived from such extension, I asked, and was authorized, to add 90 feet to the west pier before putting on the pier-head. This work will be advertised at once, and completed during the coming season. The dredged channel has been increased to a width of 200 feet. The balance that will remain after the extension of the pier will be insufficient for the completion of the dredging. The piers at this point are 470 feet apart. The shifting sand which forms the bottom readily seeks a level; I therefore propose to expend the balance, after building the crib-work, in widening the present channel, and getting 12 feet of water. To complete the dredging the whole width between piers, $35,000 will be needed, in addition to the present appropriation. This is by far the finest natural harbor in the lake, but as a port of commerce it is insignificant. To complete the present works, closing the entrance between the east shore and east pier, will require $30,000. Dredging the entire channel, (as stated,) $35,000. Necessary repair for the coming year, $10,000. Big Sodus is in the district of Oswego, 30 miles distant, and about midway between it and Charlotte. It has a light-house, about three-fourths of a mile to the west of the pier, on the main land; it should be on the pier-head. Fort Ontario (Oswego) is the nearest fort. The statistics are insignificant; they are included in those of Oswego. The interests of the place are, at present, entirely local; though, as a harbor of refuge, I consider the place of great importance. Unless the channel is dredged to its full width and uniform, annual expenditure will be required. All of the amounts asked for could be expended in one season.

Amount available for this work July 1, 1868	$58,645 46
Amount available for this work July 1, 1869	8,056 53
Amount required for year ending June 30, 1871	35,000 00

5. CHARLOTTE OR GENESEE RIVER HARBOR.

The contractors have carried out the terms of their contract in a satisfactory manner. All the work has been expended on the E pier, where

2,198 linear feet of cribs have been filled and sunk, and were decked over to retain their stone filling, as the appropriation had become exhausted. There yet remain to be done 48 linear feet of cribs, 216 linear feet of superstructure, and the pier-head, in order to complete the pier. An appropriation of $30,000 is urgently needed for this purpose, and also to relevel a portion of the west pier. Fifteen thousand dollars additional is also asked to extend the southerly end of the same pier to prevent the washing away of the banks of the river and the rear of that end of the pier; an allotment of $1,000 has been asked for.

Oswego, Ogdensburg and Charlotte are the three important harbors on the lake in regard to commerce.

All of the amounts mentioned could be profitably expended in one season.

There is a portion of the west pier, about 1,000 feet long, running from the lake shore up the river to the iron works, which I would recommend for sale at cost price to private parties for wharfage; such parties being required to make proper repairs, at their own expense, under the direction of the engineer officer in charge; the proceeds of such sale to be used for repairing the pier proper.

Charlotte is the port of entry for the city of Rochester, (6 miles distant,) in the district of Genesee; it has two lights, one on the west pier and the other on the shore, as its range. Fort Niagara, about 75 miles to the west, and Fort Ontario, about 60 miles to the east, are the nearest forts.

Duties collected during the past year	$77,115 33
Value of exports, foreign	$99,615 00
Value of exports, coastwise	$1,007 00
Value of imports, coastwise	$46,244 00
Value of imports, foreign	$351,348 00
Number of arrivals	736
Tonnage of arrivals	124,756
Number of clearances	724
Tonnage of clearances	124,077

No abstracts.

Amount available for this work July 1, 1868	$19,995 94
Amount available for this work July 1, 1869	71 80
Amount required for the year ending June 30, 1871	45,000 00

6. OAK ORCHARD HARBOR.

Owing to the failure on the part of the contractor for labor to perform his work, the contract was cancelled by Brevet Colonel C. E. Blunt, and the work relet. The loss of time consequent on this was very serious, and but little work has been done.

The gap in the west pier has been finished except the decking over. On the east pier the old superstructure has been removed, and 300 linear feet of cribs filled and sunk. At the commencement of operations this spring, three dredges were sent here, and have been working in the channel and on the line of the piers. It is proposed during the coming year to continue the work on the east and west piers, and to dredge in the channel as long as the appropriation will permit, which, it is expected, will be exhausted this coming year.

Fifty thousand dollars will be required to complete the work already proposed, (viz., dredging channel and completing piers,) all of which can be expended in one season.

This harbor is in the district of Genesee; Charlotte, 30 miles to the east, is the nearest port of entry, where is also the nearest light-house. One is required on the pier at this point. Fort Niagara, 45 miles west, is the nearest fort. This harbor is one of small natural advantages. Duties collected during year, $1,999 70.

No abstracts on file in this office for 1868.

Amount available for this work July 1, 1868	$74,793 11
Amount available for this work July 1, 1869	45,350 43
Amount required for year ending June 30, 1871	50,000 00

Abstract of contract for improving harbor of Oak Orchard, New York, for year ending June 30, 1869.

James Caldwell:

Framing timber, per lineal foot	$0 06

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

Abstract of contract for improving harbor of Oak Orchard, New York, for year ending June 30, 1869.

James Caldwell:

Driving iron, per pound	$0 01

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

Abstract of contract for improving harbor of Oak Orchard, New York, for year ending June 30, 1869.

James Caldwell:

Labor.—Timber, per lineal foot	$0 06
Iron, per pound	01

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

---

7. OLCOTT HARBOR.

Operations during the year have been directed to dredging in the channel and on line of piers, and putting down cribs and superstructure of the piers. Of the west pier, 275 linear feet of cribs and superstructure have been completed, and 70 linear feet of cribs filled without superstructure. Of the east pier but two (2) cribs had been sunk when season's operations were closed. During the winter the labor and dredging contracts were annulled.

Authority having been obtained from the department, the work will be done during the coming year by day's labor. One dredge was in operation during the season.

It is proposed during the coming year to dredge in the channel and on the line of the piers, and to carry out the east and west piers as far as will be justified by the appropriation. Amount required to complete the work, $50,000, which can be profitably expended in one season. Olcott is a port of entry in the collection district of Niagara, 18 miles distant from Fort Niagara and its light-house. (Statistics not obtained.) Abstract herewith.

Amount available for this work July 1, 1868	$50,671 67
Amount available for this work July 1, 1869	21,312 46
Amount required for the year ending June 30, 1871	50,000 00

I would earnestly recommend that in all cases the work on the lake and river be carried on by the engineer officer in charge by day's labor, and the purchase of materials in open market. And, also, that wherever appropriations be hereafter made, the United States be ceded a certain portion of land at or along the end of the pier work, and that they assume supreme control of all proposed improvements or changes anywhere within the harbor concerned, and to apply to works already built or building.

Respectfully submitted.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

OSWEGO, N. Y., *September* 30, 1869.

Abstract of contract for improving harbor of Olcott, New York, for the year ending June 30, 1869.

Pratt & Co.:

Round wrought-iron drift bolts, per pound	$0 04$\frac{5}{8}$
Wrought-iron spike, per pound	05$\frac{5}{8}$
Wrought-iron washer, per pound	06

I certify that the above abstract is correct.

NICOLAS BOWEN,
Major of Engineers and Brevet Colonel U. S. A.

APPENDIX G.

UNITED STATES ENGINEER'S OFFICE,
Burlington, Vt., August 12, 1869.

GENERAL: I have the honor to render the following report of operations upon the harbor of Plattsburg, N. Y., for the fiscal year ending June 30, 1869.

With my last annual report, I transmitted an abstract of proposals for dredging the harbor, for the purpose of removing the sand bar lying between the breakwater and south wharf. It was expected that the lowest bidder, E. B. Van Dusen, would enter into contract and perform the work in accordance with his offer. After some correspondence and

a good deal of delay, he formally declined to perfect his contract. Mr Emory R. Seward, of Albany, N. Y., the next lowest bidder, was then notified that his offer would be accepted. A contract was accordingly perfected with this gentleman, and ratified on the 5th of August, 1868.

Owing to difficulties in getting his dredge through the canal from Albany, Mr. Seward was delayed in commencing work until the 15th of September. The season was now very favorable for his operations, and the work was pushed forward by him with energy and thoroughness. He encountered large rocks, which had heretofore proved a serious obstruction to vessels; these he carefully removed by "driving" them with the dipper, either into deep water or out upon the shore, as will be seen upon referring to my sketch, sent to the department with letter of December 12, 1868. The depth of water attained in all parts of the harbor was at least seven feet. This depth renders navigation safe and easy for the present, though an additional depth of two feet would be desirable. I would respectfully renew my recommendation of last year, relative to a permanent provision against future wash of the government reservation, by erecting a dry stone revetment along its base, and to further increase the depth of the harbor to nine feet by additional dredging. The business of Plattsburg has grown rapidly during the past five years, and statements of its business men indicate a still further increase, and much greater demand for harbor facilities during coming years. It is also urgently requested that more protection to the wharfage may be furnished by an extension of the present breakwater three hundred feet to the northward. These improvements, based upon last year's estimates, would require an appropriation of $45,000, which amount will be required for the entire and permanent completion of this work.

Amount to be profitably expended upon this work during next year, $25,000.

Nearest port of entry, Plattsburg, N. Y., situated in the collection district of Champlain.

Nearest light-house at Cumberland Head.

Nearest fort, Fort Montgomery, Rouse's Point, New York.

Revenue collected at this port during last fiscal year, $544,500.

For amount of commerce and navigation of this harbor, reference is made to the accompanying statement from Maj. J. Parmenter, collector of the port. There is also accompanying an abstract of proposals.

Statement of cash received and expended during the year.

On hand July 1, 1868	$712 38	
Received from United States treasury	5,500 00	
		$6,212 38
Paid to Emory R. Seward for dredging 12,825 cubic yards, at 40 cents	5,130 00	
Surveys and suspension	400 91	
Advertising	100 62	
		5,631 53
Balance remaining on hand July 1, 1869		580 85
Amount of appropriation available June 30, 1869		$580 85
Amount required for the year ending June 30, 1871		20,000 00

COLLECTOR'S OFFICE,
Plattsburg, N. Y. August 9, 1869.

DEAR SIR: After so long a time I have the pleasure of handing you a statement of the commerce of the port of Plattsburg, for the fiscal year ending 30th June last. I found much difficulty in obtaining figures from parties doing business outside of the custom-house.

Very respectfully, your obedient servant,

J. PARMENTER, *Collector.*

Bvt. Lt. Col. J. W. BARLOW,
United States Engineers.

Exports from and imports into Plattsburg during the fiscal year ending June 30, 1869.

	Quantity.	Value.
EXPORTS.		
Lumber .... feet..	35,000,000	$420,000 00
Iron .... tons..	6,750	328,000 00
Nails .... kegs..	40 000	200,000 00
Flour .... barrels..	7,500	75,000 00
Grain .... bushels..	6,500	7,200 00
Provender .... tons..	350	7,500 00
Miscellaneous articles .... tons..	9,479	568,740 00
Total	....	1,606,440 00
IMPORTS.		
Iron ore .... tons..	10,780	$53,900 00
Coal .... tons..	3,500	28,000 00
Marble, (transitu) .... tons..	2,600	76,500 00
Goods, (Clinton Prison) .... tons..	250	16,000 00
Goods in transitu for Montreal, P. Q .... tons..	500	42,500 00
Miscellaneous articles .... tons..	10,900	760,000 00
Total	....	976,900 00

During the season of navigation, steamers carrying passengers and freight arrive and depart from eight to twelve times daily, Plattsburg being the northern terminus of said steamers.

The tonnage employed in the commerce of Lake Champlain (exclusive of vessels from Canada) is 43,500 tons, nearly all of which enters the port of Plattsburg many times during the season.

Number of vessesl engaged in this trade, with the above exception, is seven hundred and forty-three, among which are six first-class steamers of from eight hundred to twelve hundred tons burden each, and drawing from six to nine feet of water.

Duties on foreign goods entered during the year at port of Plattsburg	$544,500 00
Value of said goods	2,276,580 00
Value of exports, same time	124,958 00
Value of free goods, same time	28,540 00

Abstract of proposals for dredging harbor of Plattsburg, N. Y., opened at Burlington, Vt., June 27, 1868.

Names of bidders.	Names of securities.	Price, if received by the United States in the boats.	Price, if deposited outside breakwater in lake.
B. Van Dusen, Geddes, Onondaga Co., N. Y.	W. H. H. Gere, N. Stanton Gere, Geddes, Onondaga County, N. Y.	29 cents per cubic yard of sand.	33 cents per cubic yard of sand.
Emory R. Seward, Albany, N. Y., contractor.	James J. Belden, Henry D. Denison, Syracuse, Onondaga County, N. Y.	35 cents per cubic yard of sand.	40 cents per cubic yard of sand.
Luther Whitney, Burlington, Vt.	O. C. Mitchell, Hiram Tracy, Burlington, Vt.	....	60 cents per cubic yard of sand.

Respectfully submitted.

J. W. BARLOW,
Capt. of Engineers and Bvt. Lieut. Col. U. S. A.

Brevet or Maj. Gen. A. A. HUMPHREYS,
Brigadier General and Chief of Engineers,
Office of the Chief of Engineers, Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Burlington, Vermont, August 19, 1869.

GENERAL: I have the honor to submit the following annual report of operations upon the breakwater at Burlington, Vermont, for the fiscal year ending June 30, 1869.

At the close of the last fiscal year, the work of extending the breakwater to the northward by cribs had been commenced, with favorable prospects of completing about five hundred feet during the working season. As was anticipated the work uninterruptedly continued through the season; the completion of one crib per month being about the usual average. By the end of September four of the six cribs had been carried to a height greater than the depth of water and placed in position. During the following month the other two were successfully located. The cribs were each eighty feet in length with one exception; this was constructed one hundred feet long to make up an even five hundred feet for the season's operations, and was settled as easily and successfully as the others. No accident occurred with any of them, except a slight careening of one which had been placed just before a severe blow, and which had not received sufficient ballast to hold it firmly. No permanent injury to the structure was sustained, though to provide against a repetition of this difficulty the following cribs were temporarily planked over, and a considerable weight of stone placed upon this deck, and allowed to remain until a large proportion of the ballast had been put in. The line selected for the new work makes an angle with the north half of the old breakwater of 152 degrees. The depth of water averages thirty-one feet at low water; the structure will therefore be thirty-eight feet high, which, added to a settlement of four feet, makes the entire height of new breakwater forty-two feet. During the month of November considerable work upon the superstructure was accomplished, but owing to the early setting in of winter the contractors desired to suspend further operations until spring, leaving the structure about two feet below the proper level. I was willing to allow time for thorough settle-

ment before finishing, and, therefore, consented to this delay. The delivery of stone went on, however, until January, when all the cribs were filled to the height to which they had been constructed.

It was estimated that about $30,000 of the appropriation would be left after completing the five hundred feet commenced, and the question presented itself of continuing work during the following season under the existing contracts, or to readvertise the work for new proposals. The good conduct of the present contractors and their reasonable prices, on the one hand, and the uncertainties of receiving proposals in time to resume operations in the spring, on the other, decided me to recommend the continuance of the work with these gentlemen to the extent of the available funds. This recommendation was approved by the department, and the work has been resumed, and is now progressing favorably under the old contracts. Two cribs, each eighty feet long, will be constructed this summer, and the superstructure of the whole completed, making an addition in all of six hundred and sixty feet.

Project for continuing the improvement of the harbor.—A survey of the harbor, with a view to an extension of the old break-water, was made by Brevet Brigadier General C. B. Reese, major Corps of Engineers, in the summer of 1866. His report recommended an additional protection to the northern wharfage, which was then being largely extended, and an additional breakwater in that direction of fifteen hundred feet was then decided necessary to meet the requirements of the increasing commerce of this port. No extension in a southerly direction was then thought necessary. The recommendations contained in this report were concurred in by the board of engineers, which subsequently examined the subject, and appropriations were made for carrying on the improvement of the harbor in the water front lying south of the wharfage, but (owing to difficulties regarding its title unnecessary to discuss in this report) it could not be improved, and it was this which prevented an extension of the wharfage in that direction, and consequently made any further southern extension of the breakwater apparently unnecessary. During the last year, however, the difficulties obstructing the improvement of this portion of the water front have been removed, and preparations on a large scale are now going on for building extensive docks, warehouses, and machine shops, along the whole available extent of this front.

The citizens interested in these improvements are extremely urgent in expressing their wishes for the same protection from the violence of the lake that has been accorded to their neighbors north of them. This matter is referred to by me to indicate the importance of this part of the harbor compared with the north end, and to show the probability, as well as the justness, of an effort looking toward additional appropriation for the harbor, beyond those required to complete the extension now in progress, and which has received the approval of the department.

The subject is deemed worthy of study, and perhaps of sufficient importance to receive the consideration of a board of engineers, should the action ot such board be necessary to secure the approval of the department to any project of improvement in this direction. The construction of the northern extension is, however, of the first importance, and appropriations are ugently requested, at least of sufficient magnitude to prevent a total interruption in the progress of the work until this part of the harbor is properly protected.

The following statement from the collector of customs for this district, together with the additional statistics derived from other sources, exhibits (approximately) the commercial importance of this harbor:

CUSTOM-HOUSE, DISTRICT OF VERMONT,
Collector's Office, Burlington, Vt. August 21, 1869.

DEAR SIR: In reply to yours under date 6th instant, the following statement is submitted, which is as nearly correct as time will allow:

Number of arrivals and departures of vessels of all kinds to and from the port of Burlington, Vermont	7,090
Total tonnage of said vessels	4,180,562
Value of foreign imports into the district of Vermont	$3,217,671 00
Amount of duties received on the same	$644,931 90

We have no data from which to make a report of domestic commodities received and shipped from this port.

Very respectfully, your obedient servant,

M. P. SKEELS,
Dep. Collector.

Colonel J. W. BARLOW,
Burlington, Vermont.

The above report is for the fiscal year ending June 30, 1869.

Statement of miscellaneous articles received at this port during the year.

Lumber, feet	100,000,000
Pig iron, tons	12,350
Coal, tons	22,050
Moulding sand, tons	1,550
Iron ore, tons	5,000
Bar-iron, tons	1,000
Merchandise, tons	6,750
Wood, cords	3,000
Railroad ties	25,000
Produce, bushels	5,000

It is expected that these items will be largely increased during the coming year.

Amount required for permanent completion of the present extension, (840 feet,) based upon the cost of the work now in progress	$150,000 00
Amount to be profitably expended during next fiscal year	75,000 00

Cash on hand July 1, 1868	$14,745 78
Received during the year	46,181 32
	60,927 10
Expended during the year	48,912 16
Balance on hand June 30, 1869	12,014 94
Amount required for year ending June 30, 1871	$75,000 00

The breakwater is situated at Burlington, Vermont, in the collection district of Vermont, fifty-three miles from Fort Montgomery, Rouse's Point, New York, the nearest fort. There are two lights upon the breakwater, and a light-house carrying a Fresnel light of fourth order, situated upon Juniper Island, three and a half miles distant.

Abstract of contracts for material and labor for constructing the breakwater at Burlington, Vt

Names of contractors.	Material or labor contracted for.	Price.
R. Nelson Gere	Wrought iron bolts	4.95-100 cents per pound.
Do	Wrought iron spikes	6.8-10 cents per pound.
Jennings and Hart	Constructing and placing cribs	$4 37½ cents per 1,000 feet (b.m.)
Luther Whitney	Stone in cribs	$1 per cubic yard.
Hart and Jennings	Hemlock timber, 12 by 12	24 cents per lineal foot.
Do.	White pine timber, 12 by 12	Do.
Do.	Hemlock plank, 3-inch	$18 per 1,000 feet (b. m.)
Do.	White pine, 3-inch	$25 per 1,000 feet (b. m.)
Do.	Treenails	10 cents each.

Respectfully submitting the foregoing report, I am, general, your obedient servant,

J. W. BARLOW,
Captain of Engineers and Brevet Lieutenant Colonel U. S. A.

Brevet Major General A. A. HUMPHREYS,
Brigadier General and Chief of Engineers,
Office of the Chief of Engineers, Washington, D. C.

APPENDIX H.

UNITED STATES ENGINEER OFFICE,
Davenport, Iowa, September 20, 1869.

GENERAL: The following is a report of progress made in the works of river improvement, &c., under my charge for the fiscal year ending June 30, 1869, with an account of the steps taken for the prosecution of the work during the present working season and the probable progress that will be made therein.

At the beginning of the fiscal year ending June 30, 1869, I was conducting works under the following appropriations, with the available means as set opposite to them:

1. Survey of western and northwestern rivers	$13,723 33
2. Dredge and snag-boats on Mississippi River	15,336 93
3. Dredge and snag-boats on Wisconsin River	37,148 04
4. Removing snags and boulders from Minnesota River	17,916 26
5. Surveys for military defenses, Gettysburg	4,500 00
6. Repair, preservation, &c., of river and harbor works	26,000 00

In the spring of 1869 I also received the following additional allotments:

Surveys for military defenses, Gettysburg	$5,000 00
Repair, preservation, &c., river and harbor works, appropriated in February, 1869	36,000 00

The following is the amount disbursed during the fiscal year, including taxes reserved:

1. Survey of western and northwestern rivers	$12,369 38
2. Dredge and snag-boats on Mississippi River	15,336 93
3. Dredge and snag-boats on Wisconsin River	15,523 12
4. Removing snags and boulders from Minnesota River	17,916 26
5. Surveys for military defenses, Gettysburg	6,032 65
6. Repair, preservation, &c., of river and harbor works	29,159 81
	96,328 35

The following is the amount available from each appropriation for work under my charge at the beginning of the present fiscal year:

1. Survey of western and northwestern rivers	$1,354 00
2. Dredge and snag-boat on Wisconsin River	21,624 92
3. Removing snags and boulders from Minnesota River	724 07
4. Surveys for military defenses, Gettysburg	3,467 35
5. Repair, preservation, &c., of river and harbor works	32,840 19
6. Du Luth and Bois Fort Reservation road	10,000 00
7. Bridge at Rock Island	700,000 00
	770,010 53

The following estimates are for additional amounts that will be needed during the fiscal year, ending June 30, 1871:

For surveys on the Mississippi River, from Winona to La Crosse, thirty four miles, and for completing maps	$10,000 00
For surveys and examination, above falls of St. Anthony, to determine practicability of reservoirs	10,000 00
For completing maps of surveys already made	5,000 00
For operating two scraper and snag-boats, and necessary repairs to them, on the upper Mississippi River	36,000 00
For dams to close up channel injurious to navigation of Upper Mississippi	15,000 00
For operation of snag-boat on Wisconsin River	15,000 00
For improving navigation of Wisconsin River, by means of dams	100,000 00
For completion of removal of snags from Minnesota River	15,000 00
For remainder of the allowance of $1,000,000 for railroad and highway bridge, connecting Rock Island arsenal with Davenport	300,000 00

I will now give an account of the work done under each appropriation, and the reasons for which additional appropriations are asked.

1. UNDER APPROPRIATION FOR SURVEYS OF WESTERN AND NORTH-WESTERN RIVERS.

During the last fiscal year, the surveys were confined to the sites of the new bridges which had been built since 1866, and a partial resurvey of the old bridges, to determine what changes had taken place.

This was done as part of the duty assigned me of collecting information in relation to bridging the Mississippi between St. Louis and St. Paul. A survey was also made of Dubuque harbor and Alton harbor, which was useful not only in making a plan for preventing the injury caused by sand-bars, but in helping us to understand the general laws governing the movement of these impediments to navigation.

It is believed our surveys on the Mississippi and Wisconsin are now nearly sufficient to decide upon the best plans of improvement according to the money which may be supplied. It is very desirable, however, to complete the Mississippi survey down as far as La Crosse, as our surveys have not been carried below Winona, and there are very shoal places in this intermediate distance of thirty-four miles. Now while we have all the boats and materials on hand, and experienced men in our service, this work can be done much more economically and better than hereafter, and I have estimated for $10,000 to do this, and complete the

maps. The maps of the surveys we have made are as nearly complete as it is desirable to make them while the surveys are in progress, but at their close it will require about $5,000 more to finish them up. I have also estimated for $10,000 to make surveys and examination above the Falls of St. Anthony, with the view of ascertaining the practicability of forming large reservoirs on the head-waters of the Mississippi, to aid in keeping up the navigation at low stages. Whether practicable or not, the question has attracted a great deal of attention and interest. On the subject of western river surveys, I think it is very desirable to have some general system adopted, and a request made to Congress to maintain it by regular annual appropriations till all the navigable streams are properly surveyed. It is a kind of survey that to be worth much requires large experience and knowledge of things not generally known. The surveys that have been made are generally imperfect, and permanent marks are seldom established to which any reference can be made, after a few years have elapsed. The surveys of the rivers of the Mississippi Valley should be organized similar to our lake surveys.

2. APPROPRIATION FOR DREDGE AND SNAG BOAT ON MISSISSIPPI RIVER.

The two boats, Montana and Caffrey, were put in good order in the beginning of the season of 1868; but, before the snagging apparatus was fixed on the Caffrey, the unusually early low water called her to the work of scraping on the bars. The Montana, however, was fully fitted out with cranes and hoisting engines. It was a season that very fully demonstrated the success of this method of deepening the water on the bars by scraping where the channel was needed. The water was so low when the Caffrey commenced work, July 12th, that the large boats were stopped. She almost immediately deepened the water so as to allow them to resume. The river kept oscillating between a three and four feet depth on the bars, causing work to be done over again after every rise and fall. The Caffrey did double duty while the snagging apparatus was being put on the Montana, and thus, as it was not a year of extreme low water, the capacity of the two boats was not half required in scraping at the same time. During the season the Caffrey was employed one hundred and twelve days, the Montana sixty-seven days. I have appended the report of H. C. Long, United States civil engineer in charge of this work. It contains all the desirable detailed information concerning the operation of the boats under my charge, the opinion of prominent river men on the value of the operation, an account of the operation of another boat fitted out with a scraper by private companies to operate between St. Louis and Keokuk, of another fitted out by Colonel Macomb, United States engineers, and a report of the operations of Colonel Macomb's snag-boats, made by direction of Colonel Macomb.

During the season of 1869 the low water again called for work on the part of the Caffrey early in July, and she prevented any suspension of navigation by the largest boats. The rise which took place in August suspended her operations, and she was laid up on the 8th instant.

The Montana has, however, been kept in readiness to scrape the bars, if they again appear, and in the mean time is employed in removing snags, stumps, hanging trees, &c. The Montana and Caffrey were ordinary merchant boats, not built for the service, and though they have demonstrated the value of this method of improvement, they are not as efficient as boats could be now constructed, specially adapted to snagging. They require some additional appliances and repairs, yet I

have but estimated for the amount of funds necessary to operate them the next season. This method of improvement requires to be made every year. The bars reappear after each high water, and generally in a different place from what they were before, so that if wing-dams were used to deepen the water of one season, another set would be required the next season, and cost more than running the boats, and our boats also point out the channel by marks on the shore. Stumps and logs, too, are each year appearing in the channel, so that their removal must be made every year. The work in this respect is not unlike the light-house and buoy system along the ocean and lake coasts.

We are at considerable expense with our boats when not in use, as we are compelled to have an engineer and master always on hand.

When the rapids are improved so that these boats can go below, when not needed on the Upper Mississippi, the field of their operations could easily be extended to Cairo without greatly increased expense. All the allotments to me from appropriation for repairs, preservation, &c., ($26,000) made in 1868, have been expended under the head of dredge and snag boats on the Mississippi River, but a considerable portion of it was for completing maps of the river, and other office expenses. Several small channels in the upper part of the river draw off the water from the main channel, and it is advisable to close them up. Such are at Pig's Eye Island, Picayune Island, Boulanger's Island, Nininger Island, Prescott Island, Beef Slough, and Rolling Stone. I have, therefore, estimated for $15,000 to begin this work. It will probably require $15,000 more to complete it.

3. APPROPRIATION FOR DREDGE AND SNAG BOAT ON WISCONSIN RIVER.

Of this appropriation of $40,000 made in the spring of 1867, very little was expended that year, only one assistant being employed under it to assist on the survey of the river, and prepare himself for conducting the improvement.

The mode of operating being then untried, it was deemed sufficient to test the matter with the two boats on the Mississippi, so as to have a guide to that on the Wisconsin. A thorough survey of this river was, however, made in 1867, and a portion of this appropriation has been since used in completing the maps. Although the improvement of the navigation of the Wisconsin is feasible to a desired extent, yet, the establishment of a thorough line for communication between the Mississippi and Green Bay is a serious question. The greatest impediment to navigation now consists in the three railroad bridges and four wagon road bridges across it. These bridges, particularly the railroad ones, are badly located for navigation; their draws are too narrow, and some of them completely choked up with sand. Dams will have to be built to free the draws from sand-bars, and the bridges ultimately must be rebuilt. I have estimated for funds to make these and other dams, and wished to use these dams with the work of snagging and scraping, so that the benefit of this latter should not be lost by reason of the obstacles the bridge occasions. I had, therefore, conducted the work under this appropriation so far, with very little expenditure.

In September, 1868, I purchased the small steamboat Winneconne for $8,500. She was well calculated for pulling out snags, by reason of special machinery on board of her, designed for towing rafts. She was, however, found to draw too much water to operate well last season. This season she has been put in good order, and has gone to work at Portage, designed to clear the channel-way of snags and leaning trees;

working down stream. I have estimated for $15,000 to continue her operations next year, and for $100,000 to be used in making dams. I shall endeavor to present a full special report on this river this winter, discussing fully the plan of improving the navigation of the river, or of constructing an independent canal.

A careful reconnoissance was made in the autumn of 1868, to fill in the details where not covered by the survey of 1867, and the maps are now all nearly completed, and enable a full discussion of the subject to be made.

4. APPROPRIATION FOR REMOVING SNAGS AND BOULDERS FROM MINNESOTA RIVER.

The amount of $37,500 was appropriated in the spring of 1867 for removing these obstructions from the Minnesota River, from New Ulm to the mouth, according to the estimate sent in by me.

To do this, a contract at very reasonable rates was entered into with Mr. Sandford A. Hooper, of Belle Plaine. The rates were such that this sum would more than remove all the obstructions estimated for, but during August, 1867, a most unusual flood occurred in the Minnesota River and tributaries, which tore away acres of the bank, and precipitated the trees into the channel, so that it was found that the original estimate did not include half as many snags as were found when the work of removal began. On this account the work of removal was not carried above Mankato.

At first the work was begun at Mankato, and continued down to lower end of Hurricane Bend, distance of four miles. It was then found best to begin at the mouth of the river, and work up stream. The number of snags of all dimensions removed up to September 1, 1868, can be seen in my last annual report. During the remainder of the season there were removed as follows: 30 between 4 and 6 inches in diameter; 681 between 6 and 20 inches; 38 between 20 and 30 inches; 17 between 30 and 36 inches; 6 between 36 and 42; and 8 more than 42 inches in diameter; and 41⅓ cubic yards of boulders. This exhausted all but about $724 07 of the appropriation, which was reserved for special cases, and will all be applied this season.

There remains about 26 miles of river between Lower Le Sueur and Hurricane Bend, and all the distance above Mankato, from which to remove the snags. It is very desirable to have this work completed so as to fully realize what has been done. The Upper Minnesota Valley is just being developed, and this improvement will be of great assistance. I have therefore added an estimate of $15,000 for continuing this work.

5. APPROPRIATION FOR SURVEYS FOR MILITARY DEFENSES, BATTLEFIELD OF GETTYSBURG.

This survey is designed to furnish accurate contour lines of the most important parts of this field, embracing an area 6 miles by 5 miles. The lines are being staked out, and levelled 200 feet apart. During last autumn these lines were run 1,600 feet apart, and this season the filling in is being done, and will all be accomplished some time in October. The map of last year's survey is already made.

6. APPROPRIATION FOR THE DU LUTH AND BOIS FORT RESERVATION ROAD.

The duty of carrying on the work under this appropriation was assigned to me by orders from the Chief Engineer's office, dated April 28, 1869.

The funds were not available till July 1, but measures were immediately taken to ascertain the best way to work.

By my direction Brevet Major Stickney, United States Engineers, investigated the subject, and the following extract from his report contains all the information to be had at the time:

"The country between Du Luth and the Indian reservation is a succession of hills and swamps, with numerous small lakes interspersed. The ridges, tending nearly northeast and southwest are rocky, and for the most part quite thickly timbered with pine, white birch, and poplar; the swamps having tamarack and spruce. Parallel with these ridges, and nearly at right angles to the direction of the proposed road, are five rivers of considerable size, viz: Cloquet, White Face, St. Louis, Embarrass, and Vermilion, besides some smaller streams, all of which will require bridging. The first road made in this locality, being entirely a private enterprise, unaided by any public appropriation, was cut with the least possible expense and labor, extending from Du Luth to Vermilion Lake, and taking in its course as far as possible all the swamps, lakes, &c., it being intended only for winter travel. In the forepart of 1868, the legislature of Minnesota appropriated $5,000 for cutting out a road between the above named points. This work, under the direction of the commissioners of St. Louis County, was placed in the charge of Mr. Geo. R. Stuntz, who executed his charge in the most creditable manner, in the summer of 1868.

"Last winter the legislature appropriated an additional sum of $1,000, and about the same amount was raised by private subscription, which has also been expended upon the road. In cutting out this second road all obstacles were avoided where it could be done economically, and advantage taken of the best ground for the location of the road, and unavoidable crossings. The appropriation being small, however, considering the nature of the country, nothing could be done beyond the cutting out of the road, and corduroying some of the worst places, leaving the rivers unbridged and the swamps unimproved, and the road practicable only for winter travel. Beyond Vermilion Lake, or rather between that and the reservation, there is no road, the country is but little known, and I have not been able to gain much reliable information concerning it; but from what I have obtained, there is comparatively high land extending from Vermilion River northwest to Nett Lake, with no considerable streams and but little swamp, and heavily timbered. The usual way of communicating between Vermilion and Nett Lakes is by canoe, through a chain of small lakes, which extend, with the exception of a few small portages, from Vermilion Lake to Pelican Lake. Of the country in a direct line between Du Luth and Nett Lake I have but little information, but it appeared to be of the same character as that through which the present road passes.

"The direct distance between these two points is about 100 miles, and by the Vermilion route 130 miles, being 84 miles to Vermilion and 45 from there to Nett Lake.

"Mr. J. Ramsey, one of the commissioners appointed to locate the reservation, informs me that since its original location and surveys by Mr. Stuntz, it has been moved about 6 miles to the east, so as to include Pelican Lake, and that the buildings of the reservation are on the shores of that lake, which is six miles nearer than Nett Lake.

"If an entirely new road were made, the $10,000 appropriated would not more than cut it out and survey it, leaving the crossing of streams and swamps unimproved. Such a road the inhabitants have already, and would scarcely appreciate a second. In my opinion, the most judi-

cious outlay of the money appropriated would be to expend the major part of it on bridging the rivers, and improving the swamp crossings on Mr. Stuntz's road, to a point just this side of the second crossing of the Vermilion River, leaving sufficient to cut out a road from the latter point to Pelican Lake. Such a road would be between 115 and 120 miles in length, and would probably suit all parties interested. The travel on the road would be principally the hauling of merchandise, supplies, &c., to the Vermilion mining district, and on that part beyond Vermilion, the hauling of Indian supplies only, the nature of the country being such as to invite settlement only in the mining district.

"Mr. Stuntz gives the following as the amount of bridging required, which, from information received from other sources, is a pretty large estimate:

	Feet.
Cloquet River	250
White Face River	120
St. Louis River	150
Embarrass River	75
Vermilion, first crossing	80
Several smaller streams, about	300
	975

and about one mile of swamp crossing to be improved. With these improvements, he states, the road will be practicable for hauling light loads; (he probably means in summer, as the road is now practicable for winter travel.)"

The plan proposed by Major Stickney was recommended by me, and approved by the Chief of Engineers. Mr. Geo. R. Stuntz, so familiar with this region, and strongly recommended by every body at all acquainted with it, was appointed engineer to construct the road, by employing such labor as he required.

His report, dated August 9, says; "Thus far I have had extremely rainy weather to contend with. I made fair progress up to the 24th of July, and had repaired the road by building bridges and corduroys, and grading side-lying ground, and had cut a large portion of the timber for the heavy bridge across the Cloquet, twenty miles from Du Luth. The excessive rain of that date raised the river so that I had to move back a large portion of the timber, and suspended operations partially for three days. Since then the weather has been better, and I am in hopes to have the bridge completed this week. * * * My party are well adapted to the work, and are in good working order. The flies have been distressing, but are now nearly gone."

On September 1 Mr. Stuntz writes: "I have completed the large bridge across the Cloquet River. This bridge is 370 feet long, main span 54 feet, suspended on arch braces, well joined. This week I shall reach Big White Face River. The bridge at that stream will not delay us long, being only 120 feet in length. We have had an excessively wet season thus far; the prospect now is better, and I am pushing the work more rapidly."

On September 8 Mr. Stuntz reports: "I have repaired the road up to the forty-second mile, and have built the bridge across the Big White Face River." "I shall be compelled to increase my force about six men, in order to explore and survey the new portion of the road from the seventy-seventh mile-post on the Vermilion road to Nett Lake. We have now a prospect of much better weather, and consequently we shall be

able to make better progress. The whole country is now flooded with the excessive rains of last week, but a few days of dry weather will enable us to move again."

Mr. Stuntz has been employing about fifteen men and two yokes of oxen. Expenditures up to August 31 about $2,000. Accompanying this report is a map of the road, on a scale of 6 miles to an inch.

BRIDGE CONNECTING ROCK ISLAND ARSENAL WITH DAVENPORT.

Orders were received by me to proceed to Davenport and take charge of this work on the 13th of July last, and give my earnest attention to it. This I have done.

The laws and resolutions providing and making appropriation for this bridge required it to be for a double-track railroad, and wagon road above the railroad, and limited the cost of the bridge to $1,000,000, the averred estimate of the Rock Island Arsenal Commission. We probably cannot build such a bridge with this amount of money, and some modification of the law will have to be made by Congress, either changing the plan to a single-track railroad or increasing the limit of its cost. It is believed it is a mistake to say the commission made an estimate for such a bridge.

I have learned that a plan was submitted to the commission by Mr. Johnson, chief engineer of the Chicago, Rock Island and Pacific railroad, for a single-track railroad 16 feet wide, and a wagon road alongside, over the main river, 17 feet wide in the clear, but with no sidewalks, which bridge was to have a draw, on the pivot principle, giving two clear openings of 160 feet each; the whole to cost $1,296,292 11, from where it left the present railroad track on the Illinois side to where it joins the present track on Fifth street, in Davenport. Of this sum $1,046,317 58 was for the part over the main river, connecting Rock Island with Davenport.

When this plan was considered by the commission, objection was found to the inadequate width of the wagon way, which, it was thought, should be as great as 26 feet, with two sidewalks of 6 feet each. This would so increase the width of the pivot pier that the proposition was made to put the wagon way on top. This width of highway allowed room for a double railroad track, and this was recommended by the commission. I cannot learn that any estimate whatever was made for this enlarged bridge, but having Mr. Johnson's first estimate in my possession, and applying the same scale of prices to such parts as would be increased by the change, I find the double-track railroad, and enlarged wagon way, and sidewalk across the main river, would cost $1,785,142 67, and for the whole bridge, making connection with the existing track, $2,121,526 82.

It would then be clear, in my mind, that the commission in adopting the plan for a double-track railroad and highway 38 feet wide, (including sidewalks,) did not mean to adopt an estimate made for a single-track railroad and highway only 17 feet wide.

But in the agreement made by General J. M. Schofield, as Secretary of War, with John F. Tracy, president of the Chicago, Rock Island and Pacific Railroad Company, subsequent to the action of General Schofield as chairman of the commission, it is "provided that the aggregate cost of the said bridge shall not exceed $1,296,292 11, the estimate made by the commission appointed under the act approved June 27, 1866." As this sum is exactly that of Mr. Johnson's for the single-track railroad and narrow wagon road, it would seem that that must be what the commission estimated for.

In accordance with the directions received from you, I have designed the piers so that either bridge can be put on them as Congress may direct, and the work of construction is now in progress. The contracts for the masonry had all been made by General Rodman, and under these, according to my plan, will cost about $175,000. The piers are to be 36 feet by 7 feet on top, batter $\frac{1}{24}$ down stream, starting a semicircle in horizontal section. Up stream starting horizontal section to be two circles intersecting at the point, and tangent to the sides of the pier; described with radii equal to the width of the pier at the section, the slope of the line of the cutwater is one to one. The piers admit of two trusses being put upon them, giving a clear space of 28 feet. I have made the design so as to put the wagon way under the railroad. The railroad has an elevation on Mr. Johnson's plan 36 feet above low water.

I have placed the wagon way 30 feet above low water, and raised the railroad track so as to give 12 feet headway, which is sufficient for the wagon way. This will increase Mr. Johnson's estimate of the approaches for a single-track railroad only $33,766. The operation of putting the wagon road on top increases the cost of wagon-road approaches over Mr. Johnson's as estimated by General Rodman $142,462. My arrangement also saves a wagon-road span of 190 feet on the Davenport bank, which amounts to about $17,000. So that the difference in cost, with the wagon road underneath, amounts to $125,696 in favor of the latter plan. This plan is in every way the best, and puts the railroad so high that all the roads leading off the arsenal grounds can pass under it. No one objects to this arrangement, so I presume Congress will not hesitate to direct this change at all events.

With the clear space of 28 feet between the trusses, and the railroad above the wagon road, we make the trusses 33 feet high, so as to give plenty of head room below the top lateral bracing. The railroad floor beams furnish an intermediate system of bracing, so that we can make the vertical posts secure against vibration and buckling. We can make the wagon floor the whole 28 feet wide, put the double track on above it, and then two six-feet sidewalks on the top chord, to be reached by stairs ascending from the ends. This would require for safety a strength of bridge equal to a load of 9,000 pounds per lineal foot of bridge. Or, we can put the sidewalks 5 feet wide inside the truss, leaving an 18 feet wagon way, and then the double-track railroad as before, which would require a strength of bridge equal to a load of 7,800 pounds per lineal foot, or we can have a single-track railroad, with trusses 18 feet apart, giving a wagon road that wide, with two five-feet sidewalks outside the trusses, and this would require a strength of bridge equal to a load of 5,300 pounds per lineal foot.

The cost of these trusses will, on account of the long floor beams in the first two cases, be nearly in proportion to the load they have to carry. It is my design to advertise for proposals to build a superstructure on each plan, and I will have the results ready to present to Congress by the time it meets again. In view of the great load which the bridge will have to carry, if made according to the full requirements of the case, I have confined myself to the least spans allowed by law. It is doubtful whether I could venture to make the draw span any wider, and this being the case, there is no good reason for increasing the others. I have endeavored to keep the requirements of navigation uppermost in locating the axes of the bridge and piers. The position of this axis had been agreed upon between General Rodman and the railroad company before my taking charge, and I found that by locating the pivot pier so as to have one end rest on the island, the axis the of piers would be in the

direction of the current in a place where it maintained a nearly constant direction. The current is, as a whole, nearly at right angles with this axis of the bridge.

In some places it inclines some 3 degrees one way, and some places as much the other. The axis could only be at right angles with the stream by becoming a broken line, and it would have to change its direction with different stages of the river. It was, however, as well situated in these respects as could be expected. Observations with floats show that the eddies below the existing piers affect the course of the floats almost down to the site of the present bridge, but we made enough observations to eliminate the effect, so that we have the main course of the current such as it will be when these piers are removed. We have carefully determined the shape of the bottom of the river, and see that its form does not much affect the course of the current, except near low-water stages.

As before said, the location of the draw near the island placed the pivot pier parallel with the current on the location adopted by General Rodman and the railroad company. This was fortunate, because I had received a petition from the president of both the steamboat companies to put the draw at this place. An examination of the bed showed, too, that by putting it here, the pivot could be placed on 4 feet at low water on the edge of a ledge of rock, whereas by putting it out more in the middle of the stream, the pier would have to stand in 12 feet at low water. The pier placed on the ledge, besides causing less obstruction to the flow of the river, (which obstruction increases the velocity and changes the direction of the current,) would not only cost considerably less in masonry, but also in coffer-damming. For in the case of being next the shore, the coffer-dam can be run out from it, making the island act as one side of the coffer-dam, and this same coffer-dam answers for the abutment. This pivot pier and its protections occupy a space of near 400 feet up and down the river, and I agree with Captain James Ward, president of the Northern Packet Company, that it is, whenever practicable, best to have it next the shore. In passing between it and the island the boats escape all danger of striking the next pier toward which the large size of the pivot pier tends to direct the current. If, too, at any time, it should be desirable to correct the flow of the current past the pivot pier, two short coffer-dams could be run, one from each end of it to the shore, and that space enlarged so as to draw in more water, or contracted so as to shut it out, as the case required.

Every requirement seems to be fulfilled by this position of the pivot pier, except some of those General Rodman regards as important to the arsenal. First, he thinks it will be in the way of the landing for boats which he designed to make in the bay above the bridge. Second, he thinks steamboats will be using the inside space of the draw to drop through, (which is one of the advantages to navigation claimed for the location,) and that thus the seclusion which an arsenal ground should have will be invaded, and trouble be likely to arise between his watchmen and steamboat men, and that it will put the government to the expense of maintaining a watchman at this point. To obviate the first objection, I would suggest making the boat landing at the end of the island below the bridge, which is a very good place for it. As to the second one, I think regulations can be made that will avoid trouble. The expense of working the bridge has to be partly borne by the government, and this will require several men constantly at the draw.

These men could be so armed as to suppress any attempt of vicious men on the steamboats to interfere with the regulations on the island.

I have informed General Rodman of my choice of location. So far as I know I have given his objections, but I do not think them sufficient to change my plan. He has been most friendly and courteous to me in all our dealings, and I am sorry we cannot agree in this matter. I am informed that my arrangements are satisfactory to the railroad company.

Having located the draw spans, I make the next span, as the law requires, 250 feet in the clear. The abutment on the Davenport side I place on the line of low water. The curve of the shore is such that there is still water at all medium stages, and I think will not much obstruct the flow of the water, even at the highest floods. The great advantage to me in putting the abutment thus far out is to enable me to get down from the level, ten feet above high water, to the streets of Davenport without too much obstructing them. The city council of Davenport passed an ordinance, at my request, raising the grade of the streets opposite this abutment six feet. This makes a neat plan, with good approaches leading in four directions along the streets of Davenport. From this abutment to the 250-feet clear span next to the draw span, I have divided the space into four spans of 220¾ feet each in the clear at low water.

The piers are about nine feet thick at the low-water line, so that the lengths of spans, measured from center to center of piers, are four spans, 230 feet each, one span 260 feet, one draw span 366 feet; total of wagon-road bridge is 1,546 feet.

The width of the natural water way of the river at the site of the new bridge is 1,625 feet at the present stage, which is seven and one-half feet above low water, (about half way between high and low water,) and the area of the section is 21,590 square feet. The two abutments will stand nearly at the edge of the still water, and are 1,542 feet apart; they reduce the area of the section by 410 square feet. The section of the piers to stand in the water at present stage is 1,260 square feet, leaving an available water way of 19,920 square feet. The same things at the site of the old bridge are as follows: width of natural water way 1,425 feet; area of natural section at present stage 17,655 square feet. At the island end of the bridge, a point, projecting from the shore above, makes still water about forty feet from the shore, and on the Davenport side, a point and mill pier make still water about one hundred and thirty feet from the shore, both together reducing the practicable width of water way to 1,255 feet, and contracting the water way to 16,265 square feet. The piers in the river, allowing for their oblique position, occupy at least 2,800 square feet of the water way, so that there is left but 13,465 square feet of water way at this time. The mean velocity in the case of the two bridges would be immensely proportional to these practicable areas of section, or about as 1 to 1.48, or nearly as 2 to 3. That is, if the mean velocity at the old bridge were six miles an hour, it would be only four miles per hour at the new bridge. As the water rises, the section at the old bridge widens somewhat on the island side, while the new one will not, but the greater width of the old piers will more than compensate for this difference, and the ratio of the areas of the sections will not be much changed.

I am satisfied there is nothing to be apprehended from too great velocity of the current at my location of the draw spans, for one of the spans will not be in the swiftest part of the current. The highest velocity observed at the site of the new bridge was six feet per second, or four and one-tenth miles per hour. At this time the water was ten

feet above low water. I send a plan and profile of this bridge, but as the reports are generally printed without the diagrams, I have made the description full enough to be comprehended without them.

The contractors have commenced work on the Davenport abutment, and we expect to get two or three piers in this season, but the high water makes it uncertain whether we can do more.

I append letters from Captain W. F. Davidson, president of the Northwestern Union Packet Company, and Captain James Ward, president of the Northern Line Packet Company, urging that the draw be placed next the island.

NORTHWESTERN UNION PACKET COMPANY,
St. Paul, Minnesota, July 24, 1869.

DEAR SIR: Having learned that you have been placed in charge of the construction of the Rock Island bridge, I desire to call your attention to the importance of properly locating the draw.

I trust that from your experience you have seen the necessity that the draw should be so constructed that boats can drop through along the shore, and I have been informed that the bridge is to be so located that the channel will allow such construction. Of course it is not necessary that the draw should be where the boats actually run, but it should be built where the water is of sufficient depth at all times for the boats to pass.

I am gratified that the planning and construction of this bridge has been placed in your hands, feeling, as I do, that your experience will give us a bridge passable at all times, without danger from the wind or dark nights.

Should you desire it, I think I can secure a petition from a large number of prominent practical steamboat and river men to the above effect.

Yours, truly.

WM. F. DAVIDSON,
President of the Northwestern Union Packet Company.

General G. K. WARREN, *Davenport, Iowa.*

ROCK ISLAND, *July* 30, 1869.

DEAR SIR: Learning that you had charge of the construction of the bridge across the Mississippi River at Rock Island, I beg leave to call your attention to the fact that no bridge across the Mississippi has yet been constructed in accordance with the views of what are called river men, or the people engaged in navigating the Mississippi River. They are almost unanimous in the opinion that one end of the draw should rest on the shore pier, where the water is of proper depth and not subject to change. This would enable boats to land on dark nights and in windy weather, and drop through the draw by means of their lines with safety, and the draw should be as wide as possible.

Yours, very respectfully,

JAMES WARD,
President of the Northern Line Packet Company.

General G. K. WARREN, *U. S. A., Davenport, Iowa.*

PERSONAL REPORT OF DUTIES OF SELF AND THE DIFFERENT OFFICERS AND ASSISTANTS.

About the middle of October, 1868, I was made a member of a special Pacific railroad commission, to examine and report upon the condition of the Union Pacific railroad, the Union Pacific railroad, eastern division, and the Sioux City and Pacific railroad. This work occupied me continually till the middle of December, and while thus occupied the other works were carried on by my assistants.

The reports on the condition of the above named railroads were made to the Secretary of the Interior. On the 16th of January, 1869, I was made a member of another special commission to re-examine the Union Pacific railroad, and the Central Pacific railroad of California, and determine upon the proper line for uniting them. This duty occupied me until about the 10th of July, 1869. The reports were made to the Secretary of the Interior.

Brevet Major W. H. H. Benyaurd has just reported to me, and will be

given the duty of getting up the designs of the superstructure of the new bridge at this place.

Brevet Major Amos Stickney, United States Engineers, reported to me for duty at Saint Paul, December, 1868. He was put in charge of the office at that place during my absence. He organized and put on foot the work on the Du Luth and Bois Fort reservation road, and made a report of the information to be had relating to it; most of which I have copied in the body of this report. He assisted me in the general work of planning the new railroad, and wagon-road bridge to connect this place with the Rock Island arsenal, and has been placed in charge of the construction of the masonry.

First Lieutenant William H. Chase, United States Engineers, reported to me for duty on 1st of July, 1868. On the 12th of October, 1868, he was assigned to the duty of surveying the battle field of Gettysburg. He has been assisted in the work the present season by Lieutenant Thomas Turtle, and a detachment of engineer soldiers, temporarily detached from the command of General H. L. Abbot, United States Engineers, for that purpose. Lieutenant Chase has also been assisted by Mr. C. E. Davis, civil engineer; Mr. H. A. Frink, civil engineer; Mr. J. H. Dager, civil engineer; Mr. E. A. Chase, civil engineer; and Mr. William Hill, civil engineer.

Mr. H. C. Long, United States civil engineer, has been throughout the year in charge of the operation of the snag and scraper boats, Montana and Caffrey. He, besides, assisted in fitting out two other such boats to operate in the river below one field of duty, and also inspected and reported on Colonel Macomb's snag-boats, at his request and under his direction. He has been assisted by Captain N. F. Webb and Captain Aaron Russell, steamboat captains of largest experience.

Mr. D. W. Wellman, civil engineer, has had charge of the construction of the maps of the survey of the Wisconsin River, and plans for its improvement. He has been assisted by Mr. W. W. Rich, civil engineer.

Mr. J. P. Cotton, civil engineer, has had charge of the surveys on the Mississippi and examination of the bridges, assisted by Mr. W. Weston, civil engineer, and Mr. A. M. Scott, civil engineer.

Captain Edwin Bell has had supervision of the removal of the snags from the Minnesota River, and is at present engaged in doing the same on the Wisconsin River.

Mr. George R. Stuntz, civil engineer, has charge of the Du Luth and Bois Fort reservation road.

Mr. E. W. Warren has been the clerk in charge of the general office. The clerical work of the office is very considerable, and at times requires the joint labor of almost every one of my assistants.

Respectfully submitted.

G. K. WARREN,
Major of Engineers and Brevet Major General U. S. A.

Major General A. A. HUMPHREYS,
Chief of Engineers United States Army.

H 1.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minnesota, February 1, 1869.

GENERAL: I have the honor to present herewith a tabular statement, marked sheet No. 1 to sheet No. 10, (inclusive,) being a synopsis of

work performed by the United States dredging and snagging steamers, C. J. Caffrey and Montana, in the Upper Mississippi, above the Des Moines and Rock Island Rapids, during the last low season. (See appendix.)

Sheets Nos. 1 to 6 show the work done by the C. J. Caffrey; Nos. 7 to 10, the work done by the Montana. These tables are condensed from the log-book and snag registers of the boats, and in many cases give in a line the substance of the information contained in two or three pages. They may properly be regarded as an index to the books mentioned, to which reference can be made by day and date to the character and extent of either boat's work at any particular locality, should it be desirable to have more detailed information.

From an examination of these tables it will appear that the C. J. Caffrey was at work snagging and dredging or scraping the bars, inspecting and patrolling the river, &c., &c., from July 12, 1868, to October 31, 1868, 168 days, including Sundays, during which time her performance was as follows, viz:

Total number of days in commission	112
Total number of days snagging	28
Total number of days dredging	35½
Total number of snags extracted	113
Total number of trees cut	207
Total number of miles run	3,834
Total number of cords of wood used	812½

The Montana commenced active operations, snagging and dredging or scraping, August 26, and continued thus employed till October 31, 67 days. Several days were expended running from Dubuque to La Crosse for repairs, towing the Caffrey thither for the same purpose, and going to St. Paul, making the

Total number of days in commission	73
Total number of days snagging	29
Total number of days dredging	2
Total number of snags extracted	216
Total number of trees cut	137
Total number of miles run	2,070
Total number of cords of wood burned	457½
Total number of bushels of coal burned	500

Recapitulation of work.

Caffrey.—Snags extracted	113
Montana.—Snags extracted	216
	329
Caffrey.—Trees cut	207
Montana.—Trees cut	137
	344

The time given above does not include that expended while at the dock-yard, North La Crosse, undergoing alterations and repairs.

A day's work is estimated from sunrise to sunset; much of the running, wooding, &c., was done before the former and after dark, some-

times commencing at 4 a. m., and not leaving off till 9 and 10 p. m. The boats were not laid up Sundays except for repairs, and only in storms of rain, wind, or snow of unusual violence, and this with a small crew of officers and men, which did not admit of regular watches during the twenty-four hours, as is the custom with packet steamers.

Each boat was supplied with one of Long's scrapers. The Montana had two swinging cranes of about fifteen tons lifting power each, which were used to great advantage in raising stumps from the bed of the river, snags and logs under water, &c. She was also rigged with double cylinder and hoisting engines, which worked the cranes, and the hoisting and lowering gear of the scraper; these with the aid of her capstan, geared to and worked by the same engines, were all the extra power she possessed for snagging purposes. The Caffrey had only her capstan worked by a single-cylinder engine formerly belonging to the Montana, for snagging purposes, and to raise and lower the scraper. These boats were built for ordinary river trade, carrying passengers and freight; the Montana for the Missouri, and the Caffrey for the Tennessee; bought second-hand by the government and adapted to the service required.

The repairs and alterations referred to as having been accomplished at La Crosse, consisted in hauling the Caffrey on the ways repairing and re-calking her bottom, cutting off the forward guards, reducing the boiler and hurricane decks, taking off the texas and superfluous parts of the cabin, and generally putting her in a better condition for active operations. Her chimneys and breeching also were taken down, patched and replaced.

The guards forward, boiler deck, and hurricane roof of the Montana were similarly reduced; her hull was recalked above water-line; she was re-painted on the outside, and the hurricane deck repaired with a covering of new canvas. A double-geared hoisting engine, cylinder six by eighteen inches, was put up in place of the old single engine, which was transferred to the Caffrey, and the cranes and their gearing constructed and set up. The performance of this work on both boats was considerably delayed, by the difficulty of getting a sufficient number of skilled mechanics. On the Montana a portion was done at St. Paul. The Caffrey was wholly repaired at La Crosse, at the dock-yards of the N. W. U. Packet Company. The time thus occupied was from the date of leaving winter quarters at Dubuque, June 6, 1868, till the time each boat commenced work on the snags and bars.

When the Caffrey commenced work, (July 12,) navigation was becoming uncertain and troublesome to the larger class of boats, by reason of shoal water, on nearly all the principal bars, some fifteen in number between La Crosse and St. Paul, a distance of one hundred and eighty miles; and the newspapers and river men were clamoring for the "government boats." The first duty enjoined on Captain Russell, assisted and supervised by Captain N. F. Webb, both experienced pilots and river men, the latter of nearly forty years' active service in western rivers, was to make a thorough examination of the condition of the river, and the bars obstructing navigation between La Crosse and St. Paul.

The following depths were found on the principal bars, the best water at each crossing being given:

		Feet.
July 12, 1868.—	Black River Crossing	4
	Trempeleau, scant	4
	Rolling Stone	$3\frac{1}{2}$
	Beef Slough	$3\frac{1}{2}$
	Prescott, scant	4

		Feet.
July 12, 1868.—	Trininger	3½
	Gray Cloud, scant	3
	Red Rock	3½
	Pig's Eye	3
	Frenchman's	4

The channels were crooked and obscure, the points of the bars overlapping each other, requiring considerable search to find the deepest water; and then it was difficult to keep an ordinary steamer in it.

The Caffrey commenced scraping on her way down from St. Paul, on the 14th, and from that time till the boats were laid up in St. Paul for the winter, October 31, no serious trouble or delay from shoal water occurred to interrupt navigation; a uniform depth of four feet, which was the depth required by act of Congress, being maintained at all the bars.

The work required at any particular bar occupied more or less time, according to nature of bottom, force and direction of currents, and the extent of the shoal. Sometimes the water on the crest of the bar was sufficiently deepened in the course of an hour, then again it required the greater part of the day to effect the necessary improvement. A scrape or drag across a bar occupied from four to ten minutes. At Nininger, September 1, the Caffrey made seventy drags across the bar in five hours, or about four and one-fourth minutes each. The distance run with the scraper was about two hundred yards. To do this she had to double the distance going up and down, and raise and lower the scraper each time. This was done and the work successfully prosecuted without at any time interfering with passing boats. It was so arranged that the Caffrey made a trip from St. Paul to La Crosse and back once every week during the prevalence of the lowest stage of water, so that every bar requiring it was examined and worked at least once every two or three days. This was necessary from the occasional rise and fall of water during the season, and from the channel being cut up by badly managed and badly piloted boats.

When the channel was sufficiently dredged and put in good condition, guide boards were placed on either side of the river and along the banks, for the direction of pilots. These consisted simply of three-fourths to one-inch boards held together by cleats, about five or six feet square, painted white with a large red cross in the center, and fastened twenty or thirty feet from the ground on trees, in conspicuous places. At first considerable objection was made to these guide boards, and ridicule heaped upon them by the steamboat men and pilots, but at the close of the season there was a universal acknowledgment of their benefit, especially in dark and cloudy nights. Between the 22d September and 3d October General Warren and myself visited Madison, Wisconsin, and the route of the Wisconsin, Fox River and Green Bay Navigation Company, accompanied by Mr. B. J. Stevens, vice-president, Mr. Kelley, secretary, and Captain W. M. Edwards, engineer of said company, at which time the steamer Winneconne was purchased for the Wisconsin River improvement for $8,000.

Between the 8th and 12th of October I visited and inspected the mouth of the Wisconsin River with the steamer C. J. Caffrey, under the following letter of instructions:

UNITED STATES ENGINEER OFFICE,
St. Paul, Minnesota, October 8, 1868.

SIR: The following general instructions are furnished for your guidance and observance till an occasion may arise for their being modified or altered:

1. You will keep the steamer Montana at work removing snags and similar obstruc-

tions, cutting trees, &c., from the channel and banks of the river at such points as, in your discretion, such work seems to be called for, and scraping the bars if the water gets low enough to require it. It is expected that this boat will be actively employed as designated until the close of navigation, unless the river should rise so high, say three or four feet above present stage, as not to require her services in improving navigation any longer the present season, in which case she is to be laid up, her officers and crew paid off and discharged.

2. You will proceed with the steamer C. J. Caffrey to the mouth of the Wisconsin River, and make a thorough test of her capacity to improve the navigation of that stream by scraping the bars, and also try the practicability of ascending the stream at the present stage of water, and passing through one or more of the bridges. You are not to ascend this river more than fifteen or twenty miles, or to attempt more than can be accomplished in ten or twelve days; after which period the Caffrey will resume her regular work, snagging or scraping on the Mississippi, under the same conditions as those imposed on the Montana.

You will make a special report to me of your operations with the Caffrey on the Wisconsin, with such remarks and suggestions as you may see fit to present.

The steamer Winneconne, lately purchased at Portage, for service in the Wisconsin, is expected to be at the mouth of the river by the time of your arrival there. You may direct Captain Neff, master of said boat, to test her capabilities in extracting snags from the river, or make use of her services in any other way you deem proper, unless otherwise instructed.

When the occasion shall arise for suspending operations, you will take the Montana and Caffrey to St. Paul, there pay off and discharge officers and crew, putting the boats in suitable trim for their safety and the preservation of the engines and machinery during the winter, placing each boat in charge of a watchman, whom you may select for that purpose in the same manner and on the same terms as allowed last season.

Captain N. F. Webb will continue to act as your general assistant in the performance of the duties assigned you, on the completion of which you will report to me for further orders.

Yours, respectfully,

G. K. WARREN,
Brevet Major General U. S. A., Major of Engineers.

Major H. C. LONG, *U. S. Civil Engineer,*
In Charge Dredge and Snag-boats, Upper Mississippi River.

The Caffrey spent part of two days at the mouth of the Wisconsin, but failed to accomplish anything desirable in the way of scraping or dredging, by reason of the extreme low stage of water prevailing in that river, there being but two feet on the bars at the mouth, and for two miles up stream, which did not admit of a vessel of her draught entering. It was also found impossible to get her through the first draw-bridge, six miles up, for want of water space between the piers. For the same reason, the Winneconne, a much smaller boat than the Caffrey, failed to reach the mouth of the river at the appointed time.

The following report gives these particulars in detail:

UNITED STATES STEAMER C. J. CAFFREY,
Prairie du Chien, October 11, 1868.

GENERAL: I wrote you yesterday, announcing our arrival at this place. The same afternoon we run down to the mouth of the Wisconsin River, and grounded twice in two feet water, in trying to force an entrance; (the Caffrey rubs hard on two and a half feet water.) We then, with a yawl and the assistance of a "raft pilot" who said he had been navigating the river the last seventeen years, examined every practicable channel at the mouth, and two miles up, without finding any with over two feet water.

This morning early we resumed our examination with the yawl and skiff, (Captain Russell in charge of the former, myself with the latter,) extending them up to the first bridge, about six miles, and some three miles below the mouth of the Wisconsin to an old slough wending along the bluffs, said to have been the main channel of the river thirty or forty years ago, with no more satisfactory results than obtained yesterday. In the first six miles of the river we found a succession of large flat bars, with intervening pools or pockets of deeper water. The former are 250 to 350 feet long, with but two and two and a half feet across them; the channels through them blind, narrow, and, in some instances, run so close to the shore as to endanger a passing boat by the projecting stumps and limbs. There are also several dangerous snags in the distance mentioned.

The opening at the draw-bridge at water surface was about twenty feet at the

present stage of the river, too narrow for the Caffrey; and it seems very doubtful whether she could effect a passage at a stage of water four or five feet higher, as even then it does not appear that the water space at the draw would be over 45 or 48 feet.

The bars obstructing the mouth of the Wisconsin, as we found them, are not merely abrupt reefs, such as met with in the Upper Mississippi during low water, but extensive flats, across which it would require a much longer time than allowed in your instructions to excavate a channel through which the Caffrey could pass.

Captain Russell and the pilots were of the opinion that the peculiar flat shape of the bars in the mouth of the Wisconsin was owing to the Mississippi being higher than this river, with but very little current in the latter, and that we would find an entirely different shape to the bars with a strong current flowing out of the Wisconsin, which seems reasonable.

The cross-currents and back-water from the Mississippi would obliterate the channels made by the scraper as fast as opened. This, with other reasons stated above, and the difficulty of getting the Caffrey through the first bridge, caused us to abandon the experiment at the mouth of the Wisconsin as likely to take some time, and involve more risks than I felt at liberty to encounter.

I have no doubt of being able to push the experiment to a successful result with a boat and scraper suited to the navigation of the Wisconsin. She should not draw over fourteen or sixteen inches, and the channel, when opened by the scrapers, may be kept in place by the aid of wing-dams and stopping side-sloughs.

An examination of the slough along the bluff, which enters the Mississippi some three miles below the present mouth of the Wisconsin, leads me to suppose that a permanent channel can more easily be opened and kept in good condition in that direction, because it will flow into the Mississippi with a current approaching parallelism. The head of this slough is now choked up with drift and sand, but I am credibly informed that boats formerly entered the Wisconsin by this route.

The Caffrey started up the Mississippi again this afternoon, 11th instant, and resumed her regular work, snagging and cutting impending trees from the banks of the river.

Respectfully submitted.

HENRY C. LONG,
United States Civil Engineer.

Brevet Major General G. K. WARREN, U. S. A.,
Major of Engineers, St. Paul, Minnesota.

As the Caffrey was first at work she did the greater part of the scraping. The heaviest snagging was done by the Montana. It is not necessary to enlarge upon these particulars in this connection, as they are sufficiently shown in the tables.

It is not worth while to encumber this report with the numerous letters received in testimony of the efficient service done to the navigation of the Upper Mississippi by the Montana and Caffrey.

The following from Captain T. J. Buford, superintendent of the Northern Line St. Paul and St. Louis Packet Company, is given as a specimen of many now in possession of the undersigned:

ST PAUL, *November* 18, 1868.

DEAR SIR: It gives me great pleasure to say to you that the steamers Caffrey and Montana, with the machines known as "Long's scrapers" attached, have rendered great and valuable service in keeping the river open to moderate and large-sized steamboats during the low stages of water for the past two years. I am certain and free to say that had not the said boats been at work no moderate or large-sized steamboats could have navigated the river between La Crosse and St. Paul (a distance of one hundred and eighty miles) for at least three months of the summer seasons of 1867 and 1868.

Yours, very truly,

T. J. BUFORD,
Superintendent Northern Line Packet Company.

Major H. C. LONG.

Early in September certain bars between Keokuk and Saint Louis became very troublesome, principally Cap au Gris and Iowa Island, so much so that Captain W. L. Davidson, president of Northwestern Union Line Packet Company, and Captain Ward, president Northern Line Packet Company, applied to General Warren for the services of a scraper

boat between Saint Louis and Keokuk. As the district under General Warren's supervision did not extend below the Rapids Des Moines and Rock Island, he could not dispatch one of the boats as required, but loaned the gentlemen above mentioned one of the large scrapers which was not then in use, and the services of Mr. D. S. Stombs, head machinist, under whose supervision the apparatus was mounted, and set to work on the stern-wheel steamboat Little Giant, and operated at the joint expense of the companies represented.

The enterprise was successful, as will appear from a perusal of the following letters, viz:

Captain J. S. McCune, president Keokuk and Saint Louis Packet Company, to H. C. Long.

[Extract.]

ST. LOUIS, *September* 29, 1868.

DEAR SIR: The bearer, Mr. D. S. Stombs, has assisted us in getting the scraping machine placed upon a boat, also has shown us how to operate, and has done everything to our satisfaction.

The machine so far has worked well, and we think it will warrant us in procuring one through the government or yourself, next season, and, with our present appearance, we think we can improve the channel in low water from ten (10) to twelve (12) inches, if so, we have accomplished a good deal, &c.

J. S. McCUNE.

Major H. C. LONG,
St. Paul, Minnesota.

Captain Wm. Howard, (steamer Little Giant,) to D. S. Stombs.

[Extract.]

CANTON, LOUIS COUNTY, MO.,
October 30, 1868.

DEAR SIR: I have neglected writing to you, on account of waiting to find out their opinion in regard to the working of the machine scraper. It gives entire satisfaction. We worked two days with it, and opened out three other places, after you left me. I believe it was satisfactory to the company, and we made a new channel of (5) five feet at Cap au Gris, and Iowa Island. I think it will remain all the fall, &c.

* * * * * *

Captain WILLIAM HOWARD,
Canton, Mo.

D. S. STOMBS, *Saint Paul.*

In accordance with your instructions of November 20, 1868, I left Saint Paul for Saint Louis, for the performance of the duties indicated in the following correspondence, instructions, &c.:

OFFICE WESTERN RIVER IMPROVEMENTS, NO. 4 PUBLIC LANDING,
Cincinnati, Ohio, November 10, 1868.

GENERAL: I have the honor to report that a Long's scraper has been constructed here, and is about to be sent to Mound City, to be used on board of a boat which has just been chartered, for the purpose of dredging the bars on the Mississippi River. As this operation is new to me, I would respectfully request that Mr. H. C. Long, who has had the management of similar works for General Warren, may be ordered to report to me for the purpose of a mutual comparison, and interchange of opinions and suggestions, upon the several subjects of dredging with the "Long scraper," and of destroying snags with the improved snag-boats.

This request is made, at this time, under the supposition that General Warren's field operations are probably closing for the season, and that he would willingly accord to my request, and agree with me that it would be to our mutual benefit, and to the advantage of the public interests, and it is only with this feeling that I have ventured to make it.

I remain, general, very respectfully, &c.,

J. N. MACOMB,
General Superintendent U. S. Snag-boats, Western River Improvements.

Bvt. Maj. Gen. A. A. HUMPHREYS, *Chief of Engineers, U. S. A.,*
Headquarters Corps of Engineers, Washington, D. C.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., November 14, 1868.

GENERAL: The inclosed copy of a communication of the 11th instant, from Colonel J. N. Macomb, Corps of Engineers, is transmitted for your information. It is desirable that his wishes be complied with, if the services of Mr. H. C. Long can be temporarily dispensed with without embarrassment to you.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers, Brevet Major General United States Army.

By command of Brigadier General HUMPHREY.

Brevet Major General G. K. WARREN, *Major of Engineers, St. Paul, Minn.*

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minn., November 20, 1868.

SIR: As soon as you can leave the superintendence of the work you have charge of, under me, you will proceed to Colonel J. N. Macomb, United States Engineers, for such temporary assistance as you can give him, as desired by the Chief of Engineers, (see letter annexed.)

Very respectfully, your obedient servant,

G. K. WARREN,
Major of Engineers, &c., &c.

Major H. C. LONG, *United States Civil Engineer.*

OFFICE WESTERN RIVER IMPROVEMENTS, No. 4 PUBLIC LANDING,
Cincinnati, Ohio, November 21, 1868.

SIR: Having reported to me, in accordance with the letters and orders, copies of which are annexed, you will repair to Saint Louis, Missouri, for the purpose of uniting with Brevet Major Suter in an inspection and trial of "Long's scraper," as fitted to the dredging steamer Octavia. After which, you will proceed from Saint Louis to Cairo, Illinois, for the purpose of inspecting such of the United States snag-boats as may be in that port, and of accompanying Major Suter down the Mississippi River, to witness the working of one or more of those boats. On your return to Cairo, Illinois, you will proceed thence to Cincinnati, Ohio, and report to me in person, for the purpose of inspecting, with me, such mechanical work as we have in progress here, for the Western River Improvements; after which, you will return to Saint Louis, Missouri, and on completing at that point the duties upon which you have been called to consult with me, you will repair thence to Saint Paul, Minnesota, and report in person to General Warren.

You will please make a report, in writing, to General Warren, as soon as possible after rejoining him, and give your impressions, fully, of the boats and machinery which we are constructing and using, and make any suggestions which you may think will lead to further improvements, in order that your views may come before the Chief of Engineers, United States Army.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel Engineers, Brevet Colonel United States Army,
Gen'l Sup't U. S. Snag-boats and Western River Improvements.

Major H. C. LONG,
United States Civil Engineer, Saint Paul, Minn.

The following is my report on the performance of duties assigned me in the foregoing correspondence, viz:

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., January 1, 1869.

GENERAL: In accordance with the suggestion of Colonel John N. Macomb, corps of engineers, "General Superintendent United States Snag-boats and Western River Improvements," dated at Cincinnati, November 10, 1868, that I should be ordered to report to him for the purpose of a mutual comparison and interchange of opinions and suggestions upon the several subjects of dredging with Long's scraper, and of destroying snags with our improved snag-boats, and approval of the same, (November 14, 1868,) by the Chief of Engineers, and yourself, (November 20, 1868,) I left St. Paul for the purpose specified, on the 23d November, ultimo.

On the 27th of November I received a telegram at Alton, Illinois, from Brevet Major Charles R. Suter, corps of engineers, principal assistant to Colonel Macomb, as follows:

"ST. LOUIS, *November* 27.

"To Major H. C. LONG:

"Will be at Alton this p. m. on steamer Octavia."

Major Suter arrived at Alton this p. m., on steamer Octavia, at the time appointed.

The next day was devoted to an examination of the "Long's scraper" attached to her bows, and a trial of the same on the bar about three-quarters of a mile above the city landing.

This bar had been recently surveyed by Captain J. P. Cotton, civil engineer, and party, and its position and the depth of water on it accurately defined. It crossed the river obliquely from the Illinois shore, tending up stream, till it was met and overlapped by a smaller bar that made out from the Missouri side, thus forming quite a serious obstruction to the passage of heavily loaded steamers.

The whole was composed of light shifting sand and gravel, mixed with loam, abraded from the adjacent bottom lands on the Missouri shore. The best water across the shoalest place in the main channel was found to have a depth of but four and a half feet water, from soundings made at the time under the direction of Captain Cotton, who accompanied us during the experiment.

At this point the trial was made with the Octavia's scraper. Six successive drags or scrapes were made across the obstruction, occupying about two hours from the time we left the Alton landing till we returned. In that time the depth of water on the bar was increased to six and a half feet. I have since been informed by pilots and other river men that we so cut up and loosened the bottom of the river, that in the course of three or four days afterward the current washed out a channel ten feet in depth in the direction and along the trace scooped out by the scraper.

We find that the greater width of the river gives better facilities for maneuvering the scraper than met with above the rapids, and tends to the conviction that the machine will work equally well in the Lower as in the Upper Mississippi, the frame work which carries the cutters or baskets, the slides and drag-chains, being proportionately lengthened to accommodate a greater depth of water.

The Octavia, at the time of her visit to Alton, was under charter by government for a limited period. It had not been concluded to purchase her. On this account, the scraper was not mounted with a view to permanency, and the raising and lowering the machine from and on to the bars was accompanied by considerable delay and difficulty. The scraper had but four (4) cutters instead of five, (5,) as used in the Upper Mississippi in those of largest size. Accordingly, it was suggested to Major Suter that certain improvements be made in the apparatus for handling the machine, and that the largest size scraper be attached to her bows, after which it is confidently expected that, with proper management, the Octavia will do most efficient service in dredging the bars between Keokuk and Cairo. She is a powerful, well-built boat, light draught, commodious, and in all respects suited for this character of work.

On the 5th of December I joined Major Suter at Cairo. The next day we went to Mound City and inspected the large double-hulled snag-boat B. E. De Russy. On the 7th we started for Cairo with the Octavia for the Lower Mississippi for the purpose of observing the operations of the other snag-boats J. J. Abert and S. H. Long. We met the former at Fletcher's Landing the evening of the 8th, and remained with her that night and till about eight o'clock the next morning, during which time we went on board, examined thoroughly the details of her machinery and witnessed her operations in extracting a dangerous snag from the main channel of the river. This snag was a cottonwood tree ninety feet long, three feet two inches in diameter at butt, tapering to a few inches at the top. The Abert was about fifteen minutes in raising it from the water and placing it on the rollers between the two hulls preparatory to its being cut up and otherwise disposed of. This was not considered by any means a fair test of the capacity of the boat, as the snag was not firmly imbedded in the mud at its roots, and was under the average size and weight of many snags in this vicinity. But it served to show the method of maneuvering the boat, handling the machinery, the discipline of the officers and crew, and in these particulars was very satisfactory. On the same day (December 9) we arrived at Memphis and lay there till 10.30 next day, taking on coal, stores, &c. From this place I reported to you.

On the morning of the 11th December we overtook the snag-boat S. H. Long in Fryer's Bend, ten miles below Helena, Arkansas. After inspecting her we turned up river again, passing Memphis on the 12th, meeting and visiting the De Russy on the way down, a few miles above that city. We also made a second visit to the J. J. Abert on 13th of December, near island No. 37. At that time she had a snag on her rollers, cottonwood, measuring, exclusive of roots, very heavy and wide-spreading, one hundred and thirty feet in length, sixteen feet in circumference at the large end, and eight feet in circumference at the small end. The captain of the Abert informed me that it took them three and a half hours to get this snag on to the boat, and that it would take them about as much longer to cut it up and put it out of the way, or about seven hours' work in all to dispose of a snag of these dimensions.

In the meanwhile it had turned very cold, the mercury having been as low as 15° at Helena, Arkansas, the morning we were there. We encountered heavy floating ice about two hundred miles below Cairo, and with great difficulty reached that city on the evening of December 15.

The next day I accompanied Major Suter on the cars to Cincinnati, the Octavia having been sent to Mound City to have the alterations made in the mounting of her scraper, and to undergo other slight alterations, the boat having been purchased by the government.

On the 17th December we reported to Colonel Macomb, corps of engineers, at Cincinnati, and accompanied him and Captain Shields, head machinist, in an inspection of a light-draught machine boat, and a small stern-wheel boat for propulsion of same, building and on the ways in the upper portion of that city. We also visited the foundry and examined castings and machinery in preparation for same.

Having thus completed the duties assigned us per instructions, &c., given in the early part of this paper, I returned to St. Louis, &c., and reported to you.

I take this occasion to express the great gratification afforded by the inspection and operation of the large twin snag-boats J. J. Abert, S H. Long, and R. E. De Russy. These boats appear to be most substantially built of the best materials, and complete in all their appointments, well officered and well disciplined. They are, in many respects, great improvements over the old snag-boats, such as built by Captain H. M. Shreve, Captain J. W. Russell, and others, in that the old boats had but one set of engines, which not only propelled the boats, but worked the snagging gearing by disconnecting them with the water-wheels, whereas, in the boats built under the direction of Colonel Macomb, the propelling power is distinct from that which works the snagging apparatus, and various other time and labor-saving contrivances are introduced, such as steam-gearing for sawing up the snags before dropping them in deep water and out of the way places, steam-capstans, steam-pumps, steam-hoist for drag-chains, &c. While, as just stated, the old snag-boats had but one pair of engines to perform all the work required of them, and drive them from point to point, long distances, on the Ohio, Mississippi, Missouri, and Arkansas Rivers, involving journeys many thousand miles in the aggregate, the new boats have six pairs of engines.

This fact must be taken into consideration in estimating the comparative efficiency and amount of work performed by the two classes of boats, the old and the new.

I also, further on, refer to the difference of work, and the construction of the large double snag-boats, and those used for such purposes in the Upper Mississippi, and why it is not fair to compare work done by the former to the latter.

In point of accommodation for the officers and crew, the snag-boats of Colonel Macomb are so superior to the old that no just comparison can be instituted between the two.

In conclusion, I beg leave to say, that from opportunities afforded of conversation with river men, I am of the opinion that there is but one expression in regard to the operations of the snag-boats under Colonel Macomb and Major Suter's supervision, and that is of commendation. They have already accomplished a good deal, but much more remains to be done.

Very respectfully, your obedient servant,

HENRY C. LONG,
United States Civil Engineer.

Brevet Major General G. K. WARREN, U. S. A.,
Major Corps of Engineers, Saint Paul, Minnesota.

In accordance with instructions from General Warren, dated at Saint Paul, October 8, 1868, (see preceding pages,) the Montana and C. J. Caffrey were laid up for the season at Saint Paul, October 31, 1868, officers and crew paid off and discharged, except one watchman for each boat, charged with their care and protection against thieves and fire, and the custody of the government property on board.

At this time there was a considerable rise in the river, giving five and six feet on all bars between St. Paul and La Crosse, so that no further scraping or dredging was required, and sufficient had been done in removing dangerous snags from the main channel and bends of the river to cause no apprehension on that score till the close of navigation by ice, which then threatened to occur early in November.

The aggregate cost of alterations, repairs, and operating the Montana and Caffrey on the Upper Mississippi, during the summer and fall of 1868, was about $35,000, of which amount $12,000 may be charged to docking expenses, alterations, and repairs.

The expenses per day of each boat while snagging or scraping were about $100. The ordinary expenses of the first-class packet boats on the Upper Mississippi are from $350 to $650 per day.

Estimated cost of running Montana and Caffrey during low-water season of 1868, *covering all expenses of dockage, repairs, alterations, new machinery, &c.*

Total expenditure four months, two boats, $35,000, distributed as follows:

Dockage, repairs, &c., estimated	$12,500
Pay-roll of officers and crew, 8 months 1 boat, or 4 months 2 boats	10,000
Fuel for raising steam, 8 months 1 boat, or 4 months 2 boats (actual cost nearly)	4,500
Subsistence and all other contingent expenses, including tools, tackle, blocks, &c., &c.	8,000
Total as above	35,000

RECAPITULATION.

Repairs, &c	$12,500
Running expenses, or 225 days, at $100	22,500
	35,000

In estimating the value and extent of work performed by the Caffrey and Montana, and comparing the cost and efficiency of these boats with the large double-hulled snag-boats on the Lower Mississippi, it must be taken into account: First. That the Caffrey and Montana had three-fold duty to perform, *i. e.*, scraping, cutting trees, and snagging. Second. That in snagging they could not dispose of these obstructions by merely cutting them up and dropping them from the stern of the boat in any deep hole within convenient distance, as is the case on the Lower Mississippi. The shallowness of the Upper Mississippi, and the danger of the snags, if so treated, appearing again as more dangerous obstacles than before, did not admit of this facile mode of operation. The Montana and Caffrey, in almost every instance, had to draw the snags entirely out of water and upon the high banks of the river fifteen to twenty-five and thirty feet high. This was often the most laborious and tedious part of the day's work, and consumed more time than the mere loosening of the snag from its bed in the bottom of the river and taking it from the channel. By a reference to the tables, it will be seen that the snags in many cases were afterwards cut into cord-wood, carried on board of the boat and burned in the furnaces. Third. The Montana and Caffrey were not snag or dredge-boats built especially for the service, and had few of the many appliances and little of the machinery designed for such work. They were ordinary passenger and freight boats, and have already accomplished more than was at first anticipated.

With a few repairs, alterations, and the addition of more machinery, all at a comparatively moderate expense, these boats will, with proper care and management, do effective service for two or three seasons to come. On all which subjects I propose to report to you in detail when the occasion requires.

Respectfully submitted.

HENRY C. LONG,
United States Civil Engineer.

H 2.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minnesota, January 9, 1869.

GENERAL: There is much solicitude being felt about the permanency of the falls of St. Anthony, and as you may be called upon for information concerning this locality, I make you this special communication on the subject.

Accompanying this is a profile made from surveys by Mr. Frank Cook, civil engineer, engineer for the water power company.

The following description, with some corrections, is nearly that furnished by me to Governor William R. Marshall, of Minnesota, last January.

The rock forming the bed of the river, at and just above the falls, is a stratum of hard magnesian limestone, having a well-marked jointed structure, so as to readily separate into large blocks from fifteen to thirty feet square. Immediately in contact with and beneath this limestone is a layer of clay or soft shale about three feet in thickness. Beneath this clay is a very soft silicious sand rock, extending down an unascertained depth, probably exceeding sixty feet.

The action of the water, especially at times of highest floods, when the volume of water reaches 135,000 cubic feet a second, is continually wearing away the underlying soft rocks, and allowing the great blocks of magnesian limestone to fall into the hole excavated by the falling water. This limestone debris serves then to protect somewhat the softer rock from the action of the water, but the plunging of ice, and especially of large logs, upon this debris, pounds it up and it washes down the stream and another mass falls off from the top.

This state of things has been going on for ages past, and it is obvious to any observer that the falls have receded in this manner from Fort Snelling, a distance of about seven miles, the river having formed what the Canadians call dalles, and the Mexicans a cañon.

If the same formations I have described extended indefinitely above the present crest of the falls, the effect of this recession would only have a local importance as affecting the stability of the mills and dams. But an examination of the accompanying profile shows the fact, that the stratum of hard magnesian limestone rises entirely above the surface of the river water, a short distance above the present dam, which is built on the extreme upper end of this limestone rock remaining in the bed of the stream, and that there is but 1,100 feet of this rock left above the crest of the falls. When this shall have gone, but a few days or hours will be required to sweep away the soft material remaining, and produce a long rapid, extending far above, not merely destroying the water power, but a long reach of navigable river.

The water power company at Minneapolis, in 1860, expended between $30,000 and $40,000 upon an apron of timber and stone at the foot of the falls, but the floods in July, 1867, swept most of this away and caused the falls to recede two hundred feet. Since 1860, the recession has amounted to three hundred and seventy-five feet. One more flood like that of 1867 might complete the destruction, since only about eleven hundred feet of the protecting rock remains, and its thickness diminishes up stream. At the crest it is now only eight feet thick, whereas, in 1860, it was twelve feet thick. Its thinning out up stream is probably attended with other conditions of weakness in its structure, and when we consider the great volume of water at the flood stages, bearing along huge floating logs in large numbers, we see that there is

cause for the most serious apprehension, and that the emergency is pressing.

The threatened destruction of these falls is not an exceptional physical phenomenon in this region. Other streams, like the Chippewa River, in Wisconsin, once had falls similar to this, and have been worn back to the hard granitic rocks, leaving nothing but the dalles and rapids where the falls formerly were.

The stopping of this recession at the falls of St. Anthony is a work of difficulty and expense, and as it concerns the future navigation as well as the existing water power, it is a question for public consideration.

In my report of January 29, 1867, pp. 31, 32, (House Ex. Doc. No. 58, thirty-ninth Congress, second session,) I recommended making a survey of the Mississippi River, above the falls of St. Anthony, with the view to ascertain the practicability of constructing reservoirs to help the low-water navigation below, and at the same time determine the plan and cost of improving the navigation above the falls, and connecting the river by means of a canal with Lake Superior. I feel satisfied that the days of canals are not yet ended, the only thing necessary for their success being to have them connect long natural channels of navigation, and be of dimensions great enough to accommodate steamboats of the size used on the waters so connected.

The means furnished by Congress has not been adequate to make these surveys, and I have employed all that has been furnished me in completing the surveys previously begun.

I will therefore repeat here what facts I have in relation to the Mississippi River, above the falls of St. Anthony, taken from my former report above referred to:

"After the completion of the dam and lock at Meeker's Island, there would be required locks to elevate boats eighty feet in order to pass into the level above the mill-dam. Thence to the mouth of the Crow Wing River, a distance of one hundred and forty miles, the river slopes at an average of two and two-tenths feet per mile, and could be overcome by locks, lifting in the aggregate two hundred feet, the remainder being taken up in giving the slope required to move the water along.

"From the mouth of Crow Wing River to the outlet of Sandy Lake, one hundred and forty-five miles, the slope is one and two-tenths feet per mile, and, except in one or two places where rapids exist, can be overcome without the aid of locks. An ascent of eighty feet from Sandy Lake brings us on the dividing ridge, and then there is a descent of seven hundred feet to the level of Lake Superior. The distance across from the Mississippi to the St. Louis River, below the rapids, is about thirty miles."

In any thorough plan for giving permanency to the falls of St. Anthony, there should be provision made for locking steamboats up and down, and I would suggest that such provision should be a condition on which government takes part in such undertaking, and the means provided should therefore be liberal in amount, but I have no estimate of the amount required.

Yours, respectfully,

G. K. WARREN,
Major Eng'rs and Bvt. Major Gen. U. S. A.

Bvt. Maj. Gen'l A. A. HUMPHREYS,
Brig. Gen'l and Chief of Engineers, U. S. A.

APPENDIX I.

UNITED STATES ENGINEER OFFICE,
DES MOINES AND ROCK ISLAND RAPIDS IMPROVEMENT,
AND ILLINOIS RIVER SURVEY,
Keokuk, Iowa, August 10, 1869.

GENERAL: I have the honor to submit the following report in reference to the works under my charge, for the fiscal year ending June 30, 1869, as required by circular dated Office of the Chief of Engineers, Washington, D. C., June 12, 1869.

IMPROVEMENT OF THE DES MOINES RAPIDS OF THE MISSISSIPPI RIVER.

As the plan adopted for this improvement was fully and officially decided upon, the work commenced October 8, 1867, in accordance with said plan. No survey or re-survey has been found necessary.

The work was carried on during the entire fiscal year with variable success, by contract, and for a time by "day's labor."

For a detailed statement of the amount of work done, its progress, condition, &c., your attention is respectfully invited to the accompanying report of my assistant, Captain L. Cooper Overman, corps of engineers, in local charge.

In accordance with instructions from the Office of the Chief of Engineers, dated Washington, D. C., October 24, 1868, directing me to advertise for new proposals for excavating the prison, and constructing the embankment wall of the canal for this improvement, rendered necessary by the failure of the original contractors, Messrs. Henegan & Son, the necessary advertisement, inviting proposals for the same, to be opened November 18, 1868, was sent to six of the authorized newspapers, for six consecutive insertions in each.

An abstract of the proposals received (Appendix B) is submitted, from which it will be seen that J. J. Dull, of Harrisburg, Pennsylvania, was the successful bidder, and with whom I was directed, November 28, 1868, to enter into contract, which was done, December 12, 1868, the necessary papers having been duly signed. For detailed statements of the violation and abandonment of Messrs. Henegan & Son's contract, I would respectfully refer to my letters to the department on the subject, dated October 31, 1868, January 18, 28, 29, 1869, to Captain Overman's special report on the subject, dated October 30, 1868, and to monthly report of operations for the month of October, 1868.

In accordance with instructions dated Office of the Chief of Engineers, Washington, D. C., May 15, 1869, directing me to advertise for new proposals for furnishing stone for building the locks, &c., rendered necessary by the failure of Mr. Tobie, the original contractor, the necessary advertisement, inviting proposals for the same, to be opened May 31, 1869, was sent to six of the authorized newspapers, with orders for its insertion six times consecutively in each.

An abstract of proposals (Appendix C) is herewith submitted, from which it will be perceived that for certain reasons stated therein it was thought best to reject all bids, and to purchase the stone in open market, authority for the same having been duly obtained. This was accordingly done, and on June 10, 1869, a contract was duly entered into with Charles G. Case & Co., to furnish the necessary amount of stone. For a detailed statement of the above, I would respectfully invite your attention to the accompanying report of my assistant, Captain L.

Cooper Overman, corps of engineers, upon the subject; also to my letter to the department, dated June 8, 1869.

For the entire and permanent completion of the work, the sum of $1,410,000, in addition to the $1,185,000, already appropriated, will be required, which sum can be profitably expended during the fiscal year ending June 30, 1870, in the completion of the section work, and the locks and their appurtenances, and for the improvement of Montrose channel.

The whole amount should be appropriated without delay, as every day that is delayed necessarily delays the construction of the entire improvement, in which the commerce and navigation of the Mississippi are so much interested.

The work is located in the first collection district of Iowa.

The nearest port of entry is St. Louis, Missouri, at which place there was collected during the last fiscal year as follows:

Import duties—coin	$1,565,035 35
Tonnage — currency	25,207 69
Hospital, "	6,090 17
Inspectors, &c. "	14,978 78
Official fees, "	2,673 75
Storage, "	2,267 92
Total	1,616,253 66

Eighty-two steam vessels, with a registered capacity of 25,159.83 tons, and 143 barges and flats, of 18,610.07 tons, are officially reported as belonging to this port and the port of Galena, Illinois.

The amount of revenue collected at the latter place is reported by the surveyor of customs to have been, during the fiscal year—

For tonnage duty	$4,249 92
For marine hospital dues	1,215 39
For inspection of steam vessels	793 69
For licensed pilots and engineers	3,140 00
For sale of government property	2,000 00
Total	11,399 00

An abstract of contracts entered into during the fiscal year, marked Appendix D, is submitted herewith.

The following is an exhibit of the cash received, expended, and remaining on hand during the fiscal year ending June 30, 1869:

Amount on hand July 1, 1868	$9,956 48	Amount expended*	$332,069 71
Received from the U. S. Treasury	270,000 00	Amount deposited to the credit of the Treasurer of the United States	201 00
Received from sale of public property	201 00		
Amount due from the United States, (borrowed temporarily from the appropriation for the improvement of the Rock Island Rapids, to pay indebtedness on account of this work	52,113 23		
	332,270 71		332,270 71

* Of this amount $24,767 82 is the 15 per cent. retained from monthly estimates of work done by the contractors, and has not yet been paid them.

Statement showing the amount appropriated, expended, and the balance available for the improvement of the Des Moines Rapids of the Mississippi River, at the close of the fiscal year ending June 30, 1869.

June 30, 1869.—To amount expended since the commencement of the improvement.	$408,353 39	June 23, 1866.—By amount appropriated.	$200,000 00
June 30, 1869.—To amount retained from monthly estimates of work done by the contractors, and not available.	24,767 82	March 2, 1867.—By amount appropriated.	500,000 00
Balance available	751,878 79	July 25, 1688.—By amount allotted from the appropriation for the repair, preservation, extension, and completion of certain public works on rivers and harbors.	300,000 00
Of this amount there is appplicable to the section work *$327,479 05		April 10, 1869.—By amount allotted from the appropriation for the improvement of rivers and harbors, for the fiscal year ending June 30, 1869, and the year ending June 30, 1870.	185,000 00
To construction of lower lock 177,483 43			
To stone for the guard, middle, and lower locks †246,916 31			
751,878 79			
	1,185,000 00		1,185,000 00

* $24,114 09 of this amount was forfeited to the government by the abandonment of the contract with Messrs. William and John Henegan.

† $579 of this amount was forfeited to the government by the abandonment of the contract with Charles E. Tobie.

This improvement is naturally divided as follows:

Construction of the canal—construction of the locks—excavation of Montrose channel; and a moment's consideration will show that neither of the parts is of any advantage to navigation till all are finished.

Work has been begun on the lower lock, and upon the prism and embankment wall of the canal, and contracts have been made for furnishing cement for the lower lock, and stone for the guard, middle, and lower locks.

No work has yet been done upon the channel improvement, at Montrose, nor upon the guard and middle locks, nor can any be done till further appropriations are made, it being understood that all funds now available are pledged for other work.

In consequence of the extraordinary rains, and the continued high water during the past season, the progress made in carrying the work forward has not been as satisfactory as it otherwise would have been.

But, withal, much work has been done, and it is believed that with a favorable season next year, and the necessary appropriation of money early enough in the session to render it available by the first of March, the greater part of the work can be completed by the winter of 1870.

THE IMPROVEMENT OF THE ROCK ISLAND RAPIDS OF THE MISSISSIPPI RIVER.

The plan for the improvement of these rapids having been decided upon during the year of 1867, no survey or re-survey has been necessary, except for contractors' estimates and location of dams.

The work has been carried on during the year by Messrs. Charles G. Case & Co., under their contract, dated June 28, 1867, which, upon my recommendation, was extended December 2, 1868, so as to cover the completion of all the excavation included within the coffer-dams already constructed, or in process of construction, at Moline and Syracuse Chains.

Up to June 30, 1868, 6,898.66 cubic yards of rock had been excavated and removed from Duck Creek chain by means of a coffer dam and the Osgood chisels. During the fiscal year, 3,083.64 cubic yards, in addition

to the above, has been removed, substantially completing the improvement at this chain.

The coffer-dam at Moline Chain was completed on the 30th of July, 1868, and inclosed six acres, averaging 260 feet in width, and 950 feet in length. The water was pumped out on the 25th of August, and a careful survey of the river bottom made. The quantity of rock removed from this chain up to June 30, 1869, was 16,958.41 cubic yards, leaving about two thousand yards to be removed for the completion of the channel.

The channel at Sycamore Chain was thoroughly sounded during the summer of 1867, and the construction of a coffer-dam commenced early in the summer of 1868, completed on November 14, and the water pumped out on the 26th of December, 1868.

The work of excavating the rock was immediately commenced with a large force, and continued without delay until February 12th.

The quantity of rock removed from the area within the dam was 15,804.05 cubic yards.

The development of the dam was about 4,600 linear feet; shore line 2,400 linear feet additional, inclosing an area of about forty-five acres.

A small dam was commenced at Sycamore Chain in March, and was finished in April, from which four hundred cubic yards of rock had been removed up to June 30, 1869.

As soon as the rock remaining within this dam, estimated at about fourteen hundred yards, shall have been removed, the improvement at this chain will be completed.

The total quantity of rock excavated and removed up to the close of the fiscal year is as follows:

	Cubic yards.
At Duck Creek Chain	9,982.32
At Moline Chain	16,958.41
At Sycamore Chain	16,204.05
Total	43,144.76

For a complete and interesting description of the location, character, and manner of doing the work, together with the causes of delay, its progress, &c., I would respectfully refer you to the report of my assistant, Brevet Major Charles J. Allen, United States army, in local charge, herewith submitted, marked Appendix E.

The work is located in the second collection district of Iowa. The nearest port of entry is Chicago, Illinois, at which place the amount of customs was $655,254 20.

For a statement of the commerce and navigation which would be benefitted by the completion of this improvement, I would invite your attention to that part of my report upon the improvement of the Des Moines Rapids upon this subject.

An abstract of contracts entered into (Appendix F) is herewith submitted.

The following is an exhibit of the cash received, expended, and remaining on hand during the fiscal year ending June 30, 1869:

Amount on hand July 1, 1868	$45, 675 14	Amount expended	*$382, 868 64
Received from the United States Treasury.	339, 000 00	Balance on hand June 30, 1869	1, 806 50
	384, 675 14		384, 675 14

* Of this amount $63,014 09 is the 15 per cent. retained from monthly estimates of work done by the contractors, and has not yet been paid them.

Statement showing the amount appropriated, expended, and the balance available for the improvement of the Rock Island Rapids of the Mississippi River, at the close of the fiscal year ending June 30, 1869.

June 30, 1869.—To amount expended since the commencement of the improvement.	$390, 179 41	June 23, 1866.—By amount appropriated.	$100, 000 00
June 30, 1869.—Retained at the Treasury Department to settle accounts between this work and the internal revenue department, on account of taxes.	1, 000 00	March 2, 1867.—By amount appropriated.	200, 000 00
June 30, 1869.—To percentage retained from monthly estimates of work done by the contractors, and not available.	63, 014 09	July 25, 1868.—By amount allotted from the appropriation for the repair, preservation, extension, and completion of certain public works on rivers and harbors.	156, 000 00
June 30, 1869.—Balance available.....	136, 806 50	April 10, 1869.—By amount allotted from the appropriation for the improvement of rivers and harbors, for the fiscal year ending June 30, 1869, and the year ending June 30, 1870.	135, 000 00
	591, 000 00		591, 000 00

It is proposed during the ensuing season to complete the work yet remaining to be done at Sycamore Chain, and to remove the dams and debris; to complete the removal of the rock at the head of Moline Chain, by means of the chisels and dredges, and to remove a small patch of rock at the lower end of the chain, making the channel navigable, but not completing it; also, to begin and complete the improvement at Campbell's Chain.

It is also proposed to thoroughly sound and examine the entire stretch of river (not yet sounded) from the Rock Island railroad bridge to Le Claire, Iowa.

The estimated amount of excavation to be done during this season is as follows:

At Campbell's Chain, 9,000 cubic yards, at $11 50......	$103, 500 00
At Sycamore Chain, 2,000 cubic yards, at $13...........	26, 000 00
At Moline Chain, 1,000 cubic yards, at $10..............	10, 000 00
	139, 500 00
To which add work done at Sycamore and Moline Chains, not yet paid for..................................	36, 002 37
Amount..................................	175, 502 37
Amount available June 30............................	136, 806 50
Probable deficiency	38, 695 87

The work remaining to be done, but which cannot be commenced until further appropriations are made, is as follows:

	Cubic yards.
At Lower or Shoemaker's Chain (in round numbers)....	2, 300
At Winnebago Island	900
At Crab Island......................................	2, 000
At Saint Louis Chain................................	3, 000
At Smith's Chain....................................	8, 000
At Patches, below Sycamore Chain....................	2, 500
At Moline Chain.....................................	2, 000
Total..	20, 700

Estimating this work at $12 per cubic yard, the cost will be	$248,400 00
Add deficiency for work already done	38,695 87
Contingencies and engineering	12,904 13
In all	300,000 00

necessary to complete the work. This amount can be profitably expended during the summer and fall of the next fiscal year, and should be appropriated without delay, so that operations can be resumed by the first of March, or as soon thereafter as the stage of water in the river will permit.

From the success of the engineering operations on the upper rapids, I entertain no doubt whatever that the improvement will fully accommodate all the interests of navigation; and I am equally confident that it can be easily completed during the low-water season of 1870. Much the most difficult part of the work has already been done, and to delay its completion longer than next year will cost the farmers, and shippers of produce on the Mississippi River, more than the amount of money required. While it will require somewhat longer time to finish the more elaborate and costly improvements at the lower rapids, there is a greater necessity for the appropriation of the money required to put *all* parts of the work under contract, and to push them rapidly and simultaneously till they are completed.

True economy requires that provision should be made for paying the expense of an entire piece of work before it is begun at all, and as the money for these works cannot be drawn from the treasury any faster than it becomes due to the contractors, I can see no objections whatever to its appropriation at once. Either this should be done, or the legal prohibition removed which now prevents government officers from making contracts for more work than the money already appropriated will pay for.

If the engineer in charge of an improvement already sanctioned by Congress were permitted to contract for all the work necessary to complete the same, providing in the contract that any failure on the part of Congress to appropriate the necessary money from time to time should be at the risk of the contractor, without recourse of law for damages, it would remove much of the difficulty now experienced in contracting for work with partial appropriations, and would still enable Congress to keep the annual appropriations down to the lowest limits compatible with the requirements of the public good.

SURVEY OF THE ILLINOIS RIVER.

The field operations on the Illinois River during the past year were confined to the examination of sites for locks and dams, in connection with the improvements proposed in 1867. A field party, under charge of Civil Engineer Assistants H. A. Ulffers and G. A. Keefer, was sent out for this purpose in the latter part of September, with instructions to make full surveys of all points likely to become available for the construction of locks and dams.

The party was fitted out with the usual surveying instruments, and a small boring apparatus of thirty feet in length, to examine the bed of the river. The comparatively high stage of water, and the heavy rains prevailing during October and November, together with the unusual

severity with which winter set in early in December, prevented this party from fully accomplishing all that was expected, and one important site (that at Six Mile Island) was not reached at all.

The results of these examinations are given in the report of Civil Engineer Assistant H. A. Ulffers, dated June 15, 1869, (Appendix G,) and in the accompanying seven sheets of maps, no additional surveys being necessary on this river, except such as may be incidental in carrying out the plan of improvement recommended. No further appropriations for surveys are required. The unexpended balance in my hands can be advantageously used to pay the expense of making observations upon the influence of the high stages of the water upon the bars and bed of the river, and also in obtaining the velocity and discharge of the river during freshets.

The following statement shows the cash received, expended, and remaining on hand during the fiscal year ending June 30, 1869:

Amount on hand July 1, 1868	$695 33	Amount expended	$5,538 37
Amount received from U. S. Treasury	6,500 00	Balance on hand June 30, 1869	1,656 96
Total	7,195 33	Total	7,195 33

It may not here be out of place to state that the general assembly of Illinois, by an act approved February 26, 1869, has directed the construction of one lock and dam on the Illinois River, to form the first link in the improvements of that river, substantially conforming to the general plan of improvement recommended in my report of August 15, 1868. This lock and dam are located at Henry; the lock to be composed of hydraulic stone masonry, placed on a foundation of bearing piles, timber, and plank. The chamber is to be seventy-five feet wide at top of walls, and three hundred and fifty feet long between quoins. The dam is to be built of timber cribs filled with loose stone; to have stone abutments at each end, and to have a row of square piles driven close together on the lower side of the apron. The length of the dam will be from six hundred to eight hundred feet between abutments, thirty-five feet wide on the bottom, including fifteen feet of apron, and from eleven to fourteen feet high. Brush and gravel are to be placed on the upper side of the dam, sloping back to the bed of the river, about fifty feet above the crib work. Below the apron, brush and stone are to be filled in from the top of the lower sloping down to the bed of the river, at a distance of twenty or thirty feet. The height of the dam at Henry is designed to set the water back to a depth sufficient to flood all the bars at low water, without dredging between the dam and the town of Utica.

In order to lessen the height of the second dam contemplated, at or near the mouth of Copperas Creek, it is proposed to dredge the bars intervening to a depth sufficient to furnish seven feet of water in the pool. The dam at Henry will extend the navigation of the Illinois and Michigan Canal thirty-one miles, and with the dredging proposed will give Peoria, the most important city on the lower river, good water communication with Chicago.

This dredging, it is believed, can be accomplished with the sum of $85,000, allotted for the purpose by the general government. Former dredgings on this river by the government (in 1859) have demonstrated the fact that permanent improvements can be effected by this method. For the completion of the records of the Engineer Bureau, I herewith

submit the following reports and maps relating to the survey of the Illinois River:

1. Report of Civil Engineer Assistant R. E. McMath, dated January 10, 1868, on the hydrographic survey of the Illinois River, from La Salle, Illinois, to the Mississippi River, during the summer and fall of 1867. (Appendix H.)

2. Report of Civil Engineer Assistant H. A. Ulffers, dated May 27, 1868, upon the field operations of the survey of the Illinois River, during the summer and fall of 1867. (Appendix I.)

3. Communication of Civil Engineer Assistant R. E. McMath, dated January 25, 1868, setting forth the extent of his dissent from the conclusions of General Wilson and Mr. William Gooding, upon their plan of the improvement of the Illinois River. (Appendix J.)

4. Copy of a communication of Civil Engineer Assistant R. E. McMath, to Major General Humphreys, presenting a theory for the improvement of rivers and bars, &c., dated September 18, 1868. (Appendix K.)

5. Remarks of Civil Engineer Assistant H. A. Ulffers upon the foregoing, dated June 23, 1869. (Appendix L.)

6. Report of Civil Engineer Assistant H. A. Ulffers, dated June 15, 1869, on the survey for the examination of sites for locks and dams on the Illinois River, during the fall of 1868. (Appendix G.)

7. General map of the Illinois River, and Illinois and Michigan Canal. Scale of two inches to the mile.

8. Profile of the Illinois River, and Illinois and Michigan Canal. Scale horizontal five thousand feet to the inch, vertical fifteen feet to the inch.

9. Hydrographic maps of bars and shoals of the Illinois River, below La Salle. Five sheets on a scale sixteen inches to the mile, and one sheet on a scale of four inches to the mile.

10. Cross sections of the valley of the Illinois River, in two sheets. Scale horizontal four inches to the mile, vertical forty inches to the mile.

11. Maps of localities for locks and dams on the Illinois River, below La Salle, with profiles and sections, in seven sheets. Scale of four, eight, sixteen, and thirty-two inches to the mile.

In concluding this report, I desire to express my high appreciation of the professional ability and fidelity with which my assistants, Brevet Major Charles J. Allen and Captain L. Cooper Overman, corps of engineers; Lieutenant E. F. Hoffman, United States Army; H. A. Ulffers, civil engineer assistant, (late brevet lieutenant colonel United States volunteers,) and George A. Keefer, E. Hudson Warrall, and William Hormuth, civil engineer assistants, have discharged the various duties assigned to them from time to time.

I take pleasure in acknowledging my obligations to them, and in commending them to the favorable notice of the Chief of Engineers.

I am, general, very respectfully, your obedient servant,

J. H. WILSON,
Lieutenant Colonel and Brevet Major General U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS, *Chief of Engineers,*
Office of the Chief of Engineers, Washington, D. C.

A.—*Report of Captain L. Cooper Overman.*

UNITED STATES ENGINEER OFFICE,
Des Moines Rapids Improvements, Keokuk, Iowa, June 29, 1869.

GENERAL: I have the honor to submit the following report of the condition and progress of the work for the improvement of the Des

Moines Rapids of the Mississippi River, for the fiscal year ending June 30, 1869:

SECTION WORK.

On the 30th of June, 1868, the contractors, Messrs. Henegan & Son, had performed the following quantities of their contract work:

109,153	cubic yards of earth excavated from the prism of the canal.
1,430	cubic yards of rock excavated from the prism of the canal.
25,123	cubic yards of earth embanked from borrow pits.
1,307	cubic yards of material for lining excavated.
40,268	cubic yards of loose stone in riprap wall borrowed.
127	rods of road built as new public road.
150	rods of road partially built as new public road.
$1\frac{1}{2}$	miles of new line of railroad graded.
6.04	miles of superstructure of railroad changed.

This work had been distributed as follows:

At Nashville, 13,183 cubic yards of earth excavated from prism of canal; 1,430 cubic yards of rock excavated from prism of canal; 14,415 cubic yards of earth embanked from borrow pits; 14,494 cubic yards of loose stone in riprap wall from borrow pits; which material formed an embankment in the river 2,750 feet in length, averaging ten feet above surface of water, and twenty-five feet wide, with slopes of one and one-half to one, protected on the outside by a riprap protection covering two and one-half feet thick, and extending seven feet above the surface of the water; average depth of water, two and one-half feet.

At Sandusky, 38,218 cubic yards of earth excavated from the prism of canal; 6,000 cubic yards of loose stone in riprap wall from borrow-pits; which material formed an embankment on the flats and in the river, four thousand feet in length, averaging thirteen feet high, and twenty-two feet wide, with slopes of one and one-half to one; protected on the outside by a riprap wall averaging two and one-half feet thick, and extending seven feet above the surface of the water.

At intermediate points between Nashville and Rickey's Point, 9,000 cubic yards of loose stone in riprap wall, from borrow-pits, which was used in forming the base or toe of the riprap wall, for 3,100 feet; said toe being six feet wide on top, with slope of one to one, raised one foot above the surface of the water; average depth of water, two and one-half feet.

At Rickey's Point, 38,707 cubic yards of earth excavated from the prism of the canal; 6,852 cubic yards of loose stone in riprap wall from borrow-pits; which material formed an embankment, on the flats and in the river, 2,900 feet in length, averaging twelve feet in height, and twenty-five feet in width, with slope of one and one-half to one, protected on the outside for 1,200 feet with riprap wall, averaging ten feet above surface of water, and two and one-half feet thick. The toe of the riprap had also been extended eight hundred and fifty feet below the end of the embankment, averaging five feet wide at the surface of the water, and raised one foot above the surface of the water; average depth of water, two feet.

At Price's Creek, 15,594 cubic yards of earth excavated from the prism of the canal; 3,925 cubic yards of loose stone in riprap wall from borrow-pits; which material formed an embankment on the flats and in the river, 1,900 feet in length, averaging nine feet high and thirty feet wide, with a slope of one and one-half to one, protected on the outside, for 1,000 feet, with riprap wall averaging two and one-half

feet thick, and six feet in height. The toe of the riprap wall had also been extended 1,300 feet below the end of the earth embankment, averaging five feet wide at the surface of the water, raised one foot above the surface; average depth of water, eighteen inches.

In new line of public road and railroad, 3,451 cubic yards of earth excavated from the prism of the canal; 10,708 cubic yards of earth embanked from borrow-pits; 996 cubic yards of material for lining, from borrow-pits; with this material a new line of railroad had been built for one and one-half miles, and its superstructure changed for 0.64 mile. Also two hundred rods of public road had been built and surfaced.

The whole amount of embankment constructed on the flats and in the river was 12,770 feet long; average height, ten feet, and average width, twenty-five feet; protected on the outside, for 11,500 feet of this distance, by a riprap protection two and one-half feet thick, and averaging seven feet above the surface of the river or flats. There was also 5,250 feet of toe built in addition to the above, averaging six feet wide, with slopes of one to one, one foot above the surface of the water. Depth of water, two feet.

From the 30th of June until October 26, 1868, the work progressed slowly and unsatisfactorily, and although the contractors were somewhat interrupted during this period by excessively warm weather, the main cause of delay was their incapacity and inability to perform their work. Not only were their prices too low, but they had not sufficient means and machinery to carry on the work in a degree commensurate with its magnitude. They were repeatedly notified, both verbally and in writing, of their neglect to fulfill the requirements of their contract, and were warned that unless great improvement in the quantity of work performed was made, a violation of their contract would be declared.

Accordingly on the 20th of October, 1868, no improvement taking place, and on a verbal statement on their part that they could do no better, upon recommendation of the engineer in charge, the contract between Messrs. Henegan & Son and the government was formally declared violated and abandoned by the Chief of Engineers.

For full report and details of the above I would respectfully refer you to my special report upon this subject, dated October 30, 1868; also letters to the department, dated October 30, 1868, January 18, 28, and 29, 1869, and monthly report of operations for October, 1868.

The whole amount of work performed by Messrs. Henegan & Son from June 30 to October 26, 1868, is as follows:

Grubbing and clearing one-half of section.
Bailing and draining one-half of section.
62,515 cubic yards of earth excavated from the prism of the canal.
2,223 cubic yards of rock excavated from the prism of the canal.
5,473 cubic yards of earth embanked from borrow-pits.
340 cubic yards of lining material.
21,714 cubic yards of loose stone in riprap wall, (borrowed.)
200 cubic yards of vertical wall laid in cement.
133 rods of public road built.
0.10 miles of superstructure of railroad changed.

As this is nearly four months' work, it will not take much calculation to show how long it would have taken Messrs. Henegan & Son to finish their contract at this rate of procedure. Further comment is unnecessary.

The necessary authority having been received, it was determined, as for the best interest of the work, to continue the prosecution of it by "day's labor" until a new contract could be made, in order to keep the

laborers together and prepare the work for winter work. The necessary preparations were accordingly made, and from the 26th of October until the 24th of December the work was carried on by the government direct, without the intervention of contractors.

The whole amount of work performed from October 26, 1868, to December 24, 1868, both inclusive, being the time during which the government had possession, is as follows:

22,225 cubic yards of earth excavated from the prism of the canal.
4,816 cubic yards of rock excavated from the prism of the canal.
4,090 cubic yards of earth embanked from borrow-pit.
3,093 cubic yards of loose stone in riprap, (borrowed.)
0.703 mile of line of Keokuk and St. Paul railway changed.

Much time and labor were expended by the government during this period, in doing unprofitable but necessary work, left undone by the old contractors, and this fact will account in part for the comparatively small amount of work done, as compared with the expense account. For details I would respectfully refer to monthly reports of November and December, 1868. During the months of November and December the work was much delayed by unfavorable weather, unusually high water, and severe storms with alternate freezing and thawing, rendering the handling of earth almost impossible. The whole line of the canal was, however, left in good condition for winter work by the efforts of the government during these months.

Upon the failure of Henegan & Son, advertisements were immediately inserted in a limited number of newspapers, inviting proposals, and the bids were opened November 18, 1868, and J. J. Dull was declared the lowest bidder. The contract was duly awarded to him, and the necessary papers were signed December 12, 1868. (See abstract of proposals appended herewith.)

Immediately upon the signing of the contract Mr. J. J. Dull proceeded to make arrangements for commencing the work promptly upon the first of the year.

After some trouble he finally purchased the entire stock, machinery, &c., belonging to the old contractor, so that by January 2 work was resumed in full force.

During the month the progress made was satisfactory, considering the condition of the weather and the fact that it was the contractor's first month. The weather ever since has been unfavorable; rain and snow storms, accompanied by thawing and freezing weather, rendered the excavation pits almost impassable, and added to this the continued rains and mild weather caused the river to rise. Nothing of importance, however, occurred to delay the progress of the work, until the night of the 18th of February, when the water in the river became so high as to overflow and carry away a portion of the new bank between what is known as the "Ballinger Cross-bank" and "Grand-bank 132."

For particulars connected with this overflow, the cause, damage, &c., I would respectfully refer you to my monthly report for February, 1869.

From that time until the end of the fiscal year the work progressed with tolerably satisfactory rapidity, consideration being had for the unfavorable condition of the weather and the high stage of water in the river. The latter caused much trouble by occasioning leaks in the bank at Nashville and at "Stott's Mill," thereby flooding the excavation pits and causing an entire stoppage of work for several days.

The first of these leaks occurred at Nashville on the 20th of April; the second at the same place, on the 5th of May; and the third and last at Stott's Mill pit, on the 9th of May. For full details of the above leaks

and supposed cause of the same, method of stopping, &c., I would respectfully refer you to my reports of operations for the months of April and May, 1869.

The entire amount of work performed by J. J. Dull, under his contract, up to June 30, 1869, is as follows:

Grubbing and cleaning, $\frac{8}{11}$.
Bailing and draining, $\frac{4}{5}$.
50,380 cubic yards of earth excavated from the prism of the canal.
33,064 cubic yards of rock excavated from the prism of the canal.
880 cubic yards of earth embanked from "borrow pits."
2,600 cubic yards of material puddled.
2,176 cubic yards of loose stone in riprap, (borrowed material.)

The above is for six months' work, and, considering the weather, the quantity is satisfactory, and fair proportion of the work necessary to complete the contract in the required time.

The total amount of work done by all parties on the "section work" up to June 30, 1869, was as follows:

24,427$\frac{4}{10}$ cubic yards of earth excavated from the prism of the canal.
37,533$\frac{2}{10}$ cubic yards of rock excavated from the prism of the canal.
35,566 cubic yards of earth embanked, (borrowed material.)
67,515 cubic yards of loose stone in riprap wall, (borrowed.)
335$\frac{35}{100}$ rods of new public road constructed.
1$\frac{44}{100}$ mile of new railroad built.

This work has been distributed as follows:

At Nashville, an unfinished embankment has been built, extending down stream 3,500 feet in length, averaging ten feet above the surface of the water, twenty-five feet wide, with slopes of one and one-half to one on the outside, and one and one-quarter to one on the inside; protected on the outside by a riprap wall, averaging two and one-half feet thick, and extending seven feet above the surface of the water; and on the inside by a riprap wall for 2,600 feet, averaging ten feet in height. The prism of the canal has been correspondingly excavated by the removal of rock and earth.

At Sandusky and vicinity an unfinished embankment has been constructed in the river and on the "flats," 8,300 feet in length, averaging thirteen feet high and twenty-two feet wide, with slopes of one to one, protected on the outside for about 4,300 feet of the distance by a riprap protection, averaging seven feet above the surface of the water. The prism of the canal has been correspondingly excavated by the material removed.

At points between Nashville and Sandusky, between the up-stream end of the Sandusky dump and the down-stream end of the Nashville dump, (a distance of 6,400 feet,) the base or "toe" of the riprap wall has been placed in the river, and will average twelve feet wide on top, with slopes of one to one; average height above surface of water three feet; average depth of water two and one-half feet.

At Rickey's and vicinity, an unfinished embankment has been constructed on the "flats" and in the river, 4,500 feet in length, averaging twelve feet in height, twenty-five feet in width, with slopes of one and one-half to one, protected on the outside for 3,000 feet of the distance by a riprap wall averaging ten feet in height and two and one-half feet thick. The base or "toe" of the riprap wall has also been extended 2,500 feet below the end of the bank, averaging five feet wide at the surface of the water, and raised one foot above the surface of ordinary low water; average depth of water, two feet. The prism of the canal has been correspondingly excavated by the material removed.

At Price's Creek and Stott's Mill, an unfinished embankment on the "flats" and in the river has been built, 5,000 feet in length, averaging ten feet in height and twenty feet in width, with slope of one and one-half to one, protected on the outside by a riprap wall for its whole length. This riprap wall, extending 3,000 feet of the distance, averages two and one-half feet in thickness; average height, seven feet. On the inside the embankment is protected by a riprap wall for 800 feet of its length, averaging ten feet in height.

The prism of the canal has been correspondingly excavated by the removal of the earth and work. The whole length of the railroad required to be changed by the location of the canal has been changed, the bridge and culverts built, the ties and iron replaced, and the whole placed in good running order.

The line of public road required to be changed has also been completed and accepted by the supervisors of the county.

From the above we see that the whole amount of embankment completed up to the 30th day of June, 1869, is as follows: 22,200 feet of embankment, averaging ten feet high and twenty-five feet wide at the surface of the water, protected by a riprap wall for 20,000 feet of this distance, averaging two and a half feet thick and seven feet in height above the surface of the ordinary low water; also, 10,380 feet of "toe" or base of riprap wall has been placed in the river, averaging ten feet wide, and two and one-half feet above the surface of ordinary low water, and with an average depth below the surface of two feet, with slope of one to one.

The above is about half of the work necessary to be done in order to complete the embankment wall, and to excavate the prism of the canal for the improvement of the Des Moines Rapids of the Mississippi River.

GENERAL REMARKS.

The work has been done during this year principally by the use of cars and locomotives; the track being laid upon either the embankment or the base of the riprap wall as the case required, and extended as the work progressed. Side and end dumping cars are used for earth, and small plat-cars for stone. The locomotives are small, being built expressly for this purpose, the gauge of the track being four feet.

All things being considered, and due regard being had for the unfavorable weather, the progress made during the year has been satisfactory.

The weather during the spring has, however, been particularly unfavorable for out-door work. A mild, wet winter being followed by a rainy spring, has rendered the movement of earth very difficult, and has interfered considerably with the handling of rock.

The river was unusually high during the months of March, April, and May, and still continues so.

The average force employed during the year was as follows: One superintendent, thirteen foremen, two hundred and forty laborers, twenty-one supernumeraries with sixteen teams, one locomotive, fifty earth cars, twenty-seven stone cars, two steam pumps, and three stone boats; average number of working days two hundred and sixty-five, giving for total days' work 72,875 for men, and 4,240 for teams.

The various field operations for the above work were performed for a time by civil engineer assistants O. C. Wetmore and E. Hudson Worrall; then by E. Hudson Worrall alone.

The above gentlemen, with the necessary assistants, were employed

daily during the year in locating the line, laying out and superintending the work, making the necessary measurements, and in estimating and calculating the approximate amounts of work performed each month; all of which was performed in a satisfactory manner under the general supervision of Mr. D. C. Jenné, United States civil engineer, and myself.

The necessary maps and plans for the above work were drawn by civil assistant William Hormuth.

LOCK WORKS.

On Monday, August 17, 1868, Mr. E. Owen, to whom the contract for the labor in the construction of the lower lock was duly awarded, commenced the work by extending a guard-bank of earth across the head of the lock section.

During September, the coffer work for the dam was commenced by running out the timber dam across the foot of the lock section. Meanwhile, the work upon the guard-bank was pushed rapidly ahead. On the 10th of November the entire dam was completed, and united with the earth bank at the head and side, thus entirely inclosing the lock-pit. Pumping was immediately commenced, and the bottom exposed by the 15th of November, but owing to high water, which immediately ensued, it was thought best to flood the dam again, as it was a new one, and not thoroughly settled. The water having fallen off, it was pumped out again November 21st. For the details of this dam, and other points connected with its construction, I would respectfully refer to my monthly report for October, 1868.

On the night of November 30 a break occurred, owing to the high stage of water in the river, the head being at the time nine and a half feet, and the thickness of the dam only ten feet. The leak, however, was promptly stopped, and the entire dam strengthened by timber braces.

The bottom of the river, as exposed by pumping and blasting, shows a coarse, stratified limestone. It was covered with nearly sixteen inches of gravel, shells and sand, but this debris was to be expected, as the dam was built at the foot of the lower chain of the rapids.

Rock excavation was commenced immediately, and carried on with tolerably satisfactory success, the excavated rock being used as a rip-rap protection for the outside of the main bank, which formed the east side of the dam. On the night of December 30, a break occurred in the east bank; for particulars of which, I respectfully refer to my report for December, 1868.

On the 23d of December, the first stone was dressed, since which time, the dressing of the stone has continued slowly, owing to the difficulty experienced in getting the stone delivered in a sufficiently rapid manner. Owing to the continued high water in the river, the dam was overflowed until the 20th of January, 1869, during which time but little work was done save to continue the dressing of stone, and to fill out with earth between the shore line and lock, with borrowed material. On the 16th of February the dam was again flooded with high water, suspending the work, as in January. The dam was again pumped out, and work resumed by the first of March, and the work pushed forward with tolerable rapidity during the entire month, the weather being favorable. On March 23d, the weather being mild, the work of laying up the outside wall of the pier was commenced, a few stone having been laid December 14, 1868.

On the 3d of April the dam was again flooded by the high stage of water in the river, and the dam has remained overflowed ever since. During this time nothing has been done toward the construction of the lock, except to dress a few stone, and to continue the "filling in" between the shore line and the line of the inside face of the lock walls.

The whole amount of work performed by Mr. E. Owen, under his contract for the labor in the construction of the lower lock, up to June 30, 1869, is as follows:

Bailing and draining $\frac{13}{20}$.
2,880 cubic yards of earth excavated from lock-pit.
4,042 cubic yards of rock excavated from lock-pit.
34,718$\frac{19}{100}$ cubic yards of earth embankment from "borrow-pits."
2,150 cubic yards of loose stone in riprap walls from "borrow-pits."
29,271 cubic yards of vertical wall, laid in cement for the pier.
343 cubic yards of stone, dressed for lock walls.
760 feet b. m., white oak timber, prepared and put into the work.
600 pounds of wrought iron, handled and put into the work.

With the above material, the main embankment, forming the outside of the lock section, has been built for four hundred and seventy-five feet in length, with an average width of twenty-five feet, and an average height of thirteen feet above ordinary low water, with slope of one to one and one-quarter, covered on the outside for its entire length and height with a heavy riprap protection. The space between the shore line and the line of the lock wall has been filled in for two-thirds of the distance, with an average height of "fill" of eight feet. The vertical wall is about two hundred feet in length, and ten feet in height. The timber and iron were employed to form a "step" against which the foot of the wall rests; the timber being bolted to the rock bottom of the river. The dressed stone is merely prepared, none having as yet been laid.

The progress made has been satisfactory during the time when the contractor could work, but the work has been much delayed, and considerable time lost by the low timber dam which Mr. Owen constructed. He was advised differently, but from principles of false economy, and through the advice of others, he built only a twelve-foot dam, instead of one fifteen feet high, which was recommended by the *engineer in charge.* The additional three feet would have prevented all overflows which thus far have taken place; and other work instead of being continually delayed might have progressed regularly and rapidly from the commencement of the work to the present time.

ASSISTANTS.

The field work necessary for the above has been performed by civil assistant O. C. Wetmore, then by civil assistant George A. Keefer, and latterly by civil assistant H. A. Ulffers. The necessary plans, maps, &c., have been drawn by civil assistants G. A. Keefer, William Hormuth, and J. P. Frizell, all of which work has been performed in a satisfactory manner, under the immediate direction of Mr. D. C. Jenné, United States civil engineer, and myself.

STONE.

On the 31st of August, 1868, Mr. Charles E. Tobie, to whom the contract for furnishing the stone for the construction of the lower lock had

been duly awarded, commenced operations by the opening of a natural quarry, purchased by him near what is known as "Ballinger's Run," six miles northeast of Keokuk, and near the line of the Keokuk and St. Paul railway. The months of September, October, November, and a part of December, were expended by Mr. Tobie in opening, stripping, clearing out, and equipping his quarry, and in grading and constructing a line of railroad from his quarry to the Keokuk and St. Paul railway, a distance of about thirteen hundred feet. The first stone was delivered on December 18, 1869, and from that time until May, 1869, the stone was brought down very slowly, and in small quantities.

Much dissatisfaction was felt and expressed at the manner in which Mr. Tobie was fulfilling the terms of his contract. He had delayed the delivery so long, by the dilatory construction of his track, &c., that when he was prepared to deliver the stone the weather interfered very much with the quarrying and the handling of the stone.

No improvement, however, took place during the spring, in consequence of which the cutting and preparing of the stone by the "contractor for the labor on the lower lock" was very much delayed—the quantity delivered being so small as not to keep the cutters employed from day to day.

On the 8th of May, 1869, Mr. Charles E. Tobie formally abandoned his contract entered into the 28th day of September, 1868, to deliver stone for the construction of the lower lock, assigning as a reason for so doing the low prices at which he had agreed to deliver the stone.

The case was reported to the engineer department in Washington, and authority obtained to make a new letting immediately. An advertisement was accordingly placed in six of the leading newspapers throughout the country, naming Monday, May 31, 1869, as the day for opening the bids. Upon a canvass of the bids received it was decided to reject them all, for the reason "that the lowest bidders were not able or willing to give satisfactory evidence of their capacity to deliver the stone in the quantities and within the time required, while all other bidders proposed at too high prices." Authority having been received "to purchase the stone in open market," an agreement was, on the 10th day of June, 1869, entered into with Charles G. Case and F. D. Van Wagenen, to furnish all the stone required for the lower lock, and face and backing stone for the upper and middle locks, so far as the sum (less the necessary contingencies) of $200,000 would pay for the same. For details I would respectfully refer to official letter and report of operations for June, 1869. Up to June 30, 1869, no stone had been delivered by Messrs. Case & Co., the unfavorable weather and necessary preparations preventing.

The whole quantity of stone delivered by Mr. Charles E. Tobie, from the date of his contract to the time that he abandoned the same, was as follows:

331.92 cubic yards of face stone.
335.34 cubic yards of backing stone.
41.63 cubic yards of slope wall stone.

As this was over eight months' work, and the proportion necessary to be delivered in each and every month was eleven hundred and thirty-three cubic yards, it is evident that he had not fulfilled, nor could not fulfill, his contract in any reasonable time.

The stone delivered by Mr. Tobie was a first-rate quality of magnesian limestone, of the "Keokuk group," and is well adapted, and fully complies with the specification as to quality, for the purposes for which it is intended.

Messrs. Case & Co. have purchased the quarry, with its tools, machinery, track, &c., of Mr. Tobie, and are preparing to extend and work it extensively. The appearances are, that that quarry alone will be able to furnish all the stone required.

Messrs. Case & Co. have, however, opened another quarry near Nashville, Lee County, Iowa, from which they propose to obtain stone for the upper lock, situated near Nashville.

The inspection, selection, and measurements of the stone thus far delivered have been made by civil assistant George A. Keefer, under my immediate supervision, until the date of his resignation. Since that time they have been made by Second Lieutenant Joseph E. Griffith, United States Corps of Engineers.

PROBABLE OPERATIONS DURING THE PRESENT WORKING SEASON.

Upon the "section work" steps have been taken to largely increase the amount of work in each month as soon as the water in the river permits. The contractors have been required to increase their appliances, and have now two locomotive engines for hauling earth and stone; some sixty dirt cars and the same number of stone cars, and iron. &c., sufficient to lay a track for the same over four miles in length. About three miles of track is already down and in use.

If favorable weather and a low stage of water ensues for the remainder of the year the whole of the appropriation will be expended by January 1, 1870, and the "section work" about two-thirds finished. The working season for section work is continued throughout the year, as winter interferes but little with the excavation of rock from the prism of the canal, the largest item of the work.

Upon the lock work preparations are already made to push the work with great rapidity, as soon as the stage of the water will permit.

The contractor has all the necessary machinery for doing work rapidly, including steam derricks, and "Burleigh's patent steam drill," for rock drilling, a description of which was given in my report of operations for the month of February, 1869. All the other necessary appliances are on the ground.

It is hoped that by November 15, (the usual close of the working season for such work in this latitude,) work to the amount of $100,000 will be finished, which expenditure will complete all the necessary excavation for the lock, chamber and walls, prepare the masonry, embankment, lay up and complete the pier at the foot of the lock, and probably lay the foundation, and the first course of the lock walls proper.

The dressing of stone for the pier and lock will be continued as rapidly as the stone is delivered.

The present arrangements for the delivery of stone, it is hoped, will be sufficient to push forward its delivery to the lower, middle, and guard locks, at rapid rates. It is anticipated that by January 1, 1870, about $150,000 worth of stone will be delivered at the various locks.

Preparations are being made to commence cutting the stone for the middle and upper locks, by "days' labor," as soon as Messrs. Case & Co. deliver the stone, and to push the cutting as rapidly as the delivery will allow. The excavation of the lock pits for the middle and upper locks will also be commenced during the present working season.

LAND DAMAGES.

The commission of six freeholders appointed April 28, 1868, by the sheriff of Lee County, Iowa, under the laws of the State, to assess and

decide claims for land damages, completed their labors about the 7th of September, 1868, having been in session during that time forty-two days, not consecutively. They found and acted upon forty-one claims, the originals of which, together with an abstract showing the quantity of land damages, description of property, amount claimed, estimated prices and action of commissioners in each case, were duly forwarded to the department October 17, 1868.

By letter dated Headquarters Corps of Engineers, Washington, October 28, 1868, you were authorized to settle with claimants at the assessed value, "first tendering claimants payment in accordance with your estimated value." A copy of the letter with the necessary instructions was accordingly given to Daniel F. Miller, esq., the assistant United States attorney, who had had the legal business pertaining to these claims in charge. The necessary deeds, quit-claims, &c., were prepared and vouchers for the claims were paid as presented, the government taking a title in fee simple for all land appropriated.

Thirty-nine of these claims have already been settled, at an aggregate cost to the United States of $32,983 02, including attorney's fees, commissioner's fees, &c. Of the remaining three unsettled claims, two are in dispute, and the other has not been called for.

All of which is respectfully submitted.

Very respectfully, your obedient servant,

L. COOPER OVERMAN,
Captain Corps of Engineers.

Brevet Major General J. H. WILSON,
Lieutenant Colonel United States Army.

B.—*Abstract of proposals received Wednesday, November 18, at the United States Engineer's office at Keokuk, Iowa, for labor of the section work of the canal for the improvement of the Des Moines Rapids of the Mississippi River.*

Number.	Name and residence of bidders.	Name and residence of guarantors.	Section—Grubbing and clearing.	Section—Bailing and draining.	430,000 cubic yards earth excavation.		213,000 cubic yards rock excavation.		131,000 cubic yards earth embankment.	
			Amount.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.
1	J. J. Dull, Harrisburg, Pa.*	W. D. Thompson, S. H. Walters, Harrisburg, Pa.	$1,100	$5,000	$0 40	$172,000	$2 50	$532,500	$0 40	$52,400
2	Ross, Steele & Co., Brookfield, Linn County, Mo.†	R. M. Steele, John Ross, St. John's, Clinton Co., Mich.	100	7,000	60	258,000	2 60	553,800	48½	63,535
3	Angus, Peter McDonald & Son, Toronto, Canada.	John Ross, St. John's, Clinton County, Mich.; Alexander Ross, Toronto, Canada.	....	15,000	56	240,800	2 40	511,200	50	65,500
4	James McDonald, Albany, N. Y.	Peter V. Fort, Emery G. Radcliffe, Albany, N. Y.	7,000	30,000	70	301,000	3 50	746,500	70	91,700
5	Sheehan & Loler, St. Louis, Mo.	F. Filley, James W. Bell, St. Louis, Mo.	300	15,000	65	279,500	2 48	528,240	45	58,950
6	Barnard & Gowan, Chicago, Ill.	F. W. Breckenridge, H. W. Dodge, Chicago, Ill.	700	17,000	90	387,000	3 00	639,000	60	78,600
7	John Cooper, Mt. Vernon, Ohio	Charles Cooper, G. A. Jones, Mt. Vernon, Ohio.	650	35,000	55	236,500	2 42	515,460	50	65,500
8	Willard Johnson, Fulton, N. Y.	Dervois DeWolf, W. S. Nelson, Fulton, N. Y.	500	10,000	50	215,000	3 25	692,250	50	65,500
9	John E. Harroun, Fulton, N. Y.	F. D. Van Wagenen, Elliott Harroun, Fulton, N. Y.	1,000	10,000	60	258,000	3 25	692,250	40	52,400
10	Reynolds, Saulpaugh & Co., Rock Island, Ill.	Ira M. Gifford, Davenport, Iowa, James Ward, St. Louis, Mo.	1,500	35,000	75	322,500	4 50	958,500	65	85,150
11	Norris G. Dodge, Cleveland, Ohio	Charles Pardee, Henry I. Hubbard, Skaneateles, N. Y.	1,500	38,000	66	283,800	2 40	511,200	75	98,250
12	William Lee & Co., Randolph, N. Y.	S. C. Walker, Harry Fox, Chicago, Ill.	1,200	45,000	64	275,200	2 30	489,900	25	32,750
13	Dodge, Lord & Co., Cincinnati, Ohio	Orlando Smith, Benjamin B. Frost, Chillicothe, Ohio.	1,500	15,000	70	301,000	2 25	479,250	70	91,700
14	John L. Zwart, Keokuk, Iowa‡	John McCune, George Williams, Keokuk, Iowa.	1,000	24,000	49	210,700	3 25	500,550	54	70,740
15	George Williams, Keokuk, Iowa§	John McCune, John L. Zwart, Keokuk, Iowa.	1,500	40,000	70	301,000	1 50	319,500	50	65,500
	Patrick Gibbons, & Co., Keokuk, Iowa.‖	John D. Thurmond, Isaac N. Armentrout, Keokuk, Iowa.	600	15,000	45	193,500	2 25	479,250	12½	16,385

B.—*Abstract of proposals received Wednesday, November 18, at the United States Engineer's office at Keokuk, Iowa, for labor, &c.*—Continued.

Number.	Name and residence of bidders.	Name and residence of guarantors.	10,000 cubic yards lining.		25,000 cubic yards puddling.		87,000 cubic yards loose stone in riprap wall.		500 cubic yards—Constructing slope wall.		800 cubic y'ds—Constructing vertical or battered wall laid in cement.	
			Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.
1	J. J. Dull, Harrisburg, Pa*	W. D. Thompson, S. H. Walters, Harrisburg, Pa.	$0 50	$5,000	$0 50	$12,500	$1 00	$87,000	$2 25	$1,125	$6 00	$4,800
2	Ross, Steele & Co., Brookfield, Linn County, Mo.†	R. M. Steele, John Ross, St. Johns, Clinton County, Mich.	55	5,500	25	6,250	1 05	91,350	6 00	3,000	8 00	6,400
3	Angus, Peter McDonald & Son, Toronto, Canada.	John Ross, St. Johns, Clinton County, Mich., Alexander Ross, Toronto, Can'a.	25	2,500	40	10,000	1 50	130,500	1 25	625	3 00	2,400
4	James McDonald, Albany, N. Y	Peter V. Fort, Emory G. Radcliffe, Albany, N. Y.	70	7,000	40	10,000	1 00	87,000	2 50	1,250	6 00	4,800
5	Sheehan & Loler, St. Louis, Mo	F. Filley, James W. Bell, St. Louis, Mo	65	6,500	30	7,500	1 90	165,300	4 00	2,000	7 00	5,600
6	Barnard & Gowan, Chicago, Ill	F. W. Breckenridge, H. W. Dodge, Chicago, Ill.	1 00	10,000	45	11,250	2 10	182,700	5 50	2,750	10 00	8,000
7	John Cooper, Mt. Vernon, Ohio	Charles Cooper, G. A. Jones, Mt. Vernon, Ohio.	60	6,000	25	6,250	1 75	152,250	2 00	1,000	5 00	4,000
8	Willard Johnson, Fulton, N. Y	Dervois DeWolf W. S. Nelson, Fulton, N. Y.	60	6,000	20	5,000	1 40	121,000	3 00	1,500	6 00	4,800
9	John E. Harroun, Fulton, N. Y	F. D. Van Wagenen, Elliott Harroun, Fulton, N. Y.	60	6,000	20	5,000	2 00	174,000	4 00	2,000	6 00	4,800
10	Reynolds, Saulpaugh & Co., Rock Island, Ill.	Ira M. Gifford, Davenport, Iowa, James Ward, St. Louis, Mo.	75	7,500	25	6,250	3 00	261,000	3 50	1,750	12 00	9,600
11	Norris G. Dodge, Cleveland, Ohio	Charles Pardee, Henry L Hubbard, Skaneateles, N. Y.	1 10	11,000	30	7,500	2 45	213,150	3 00	1,500	10 00	8,000
12	William Lee & Co., Randolph, N. Y	S. C. Walker, Harry Fox, Chicago, Ill	28	2,800	25	6,250	1 75	152,250	4 00	2,000	7 50	6,000
13	Dodge, Lord & Co., Cincinnati, Ohio	Orlando Smith, Benjamin B. Frost, Chillicothe, Ohio.	1 25	12,500	2 00	50,000	2 25	195,750	8 00	4,000	15 00	12,000
14	John L. Zwart, Keokuk, Iowa‡	John McCune, George Williams, Keokuk, Iowa.	65	6,500	46	11,500	1 49	129,630	2 25	1,125	5 00	4,000
15	George Williams, Keokuk, Iowa§	John McCune, John L. Zwart, Keokuk, Iowa.	1 00	10,000	4 00	100,000	1 50	130,500	5 00	2,500	18 00	14,400
	Patrick Gibbons & Co.. Keokuk, Iowa.‖	John D. Thurmond, Isaac N. Armentrout, Keokuk, Iowa.	65	6,500	20	5,000	2 00	17,400	4 00	2,000	6 00	4,800

* Lowest known to be responsible.
† 15 per cent. added by bidder for contingencies and profits.
‡ Same as George Williams, below.
§ Nos. 14 and 15 appear to be one and the same parties, the principal of one being surety of the other
‖ Irresponsible; proposal not in duplicate, Gibbons & Co. being whisky men, not contractors.

B.—*Abstract of proposals received Wednesday, November* 18, *at the United States Engineer's office at Keokuk, Iowa, for labor, &c.*—Continued.

Number.	Name and residence of bidders.	Name and residence of guarantors.	500 cubic yards—Constructing vertical or battered wall laid dry.		200 cubic yards concrete masonry.		1 mile—Changing line of railroad.	600 rods—Constructing public road.		Aggregate.
			Rate.	Amount.	Rate.	Amount.	Amount.	Rate.	Amount.	
1	J. J. Dull, Harrisburg, Pa*	W. D. Thompson, S. H. Walters, Harrisburg, Pa.	$5 00	$2,500	$4 00	$800	$450	$3 00	$1,800	$878,975
2	Ross, Steele & Co., Brookfield, Linn County, Mo.†	R. M. Steele, John Ross, St. Johns, Clinton County, Mich.	7 00	3,500	7 00	1,400	....	2 00	1,200	1,000,835
3	Angus, Peter McDonald & Son, Toronto, Canada.	John Ross, St. Johns, Clinton County, Mich., Alexander Ross, Toronto, Canada.	2 00	1,000	5 00	1,000	2,000	......	4,000	986,525
4	James McDonald, Albany, N. Y.	Peter V. Fort, Emory G. Radcliffe, Albany, N. Y.	6 00	3,000	6 00	1,200	2,500	10 00	60,000	1,352,950
5	Sheehan & Loler, St. Louis, Mo.	F. Filley, James W. Bell, St. Louis, Mo.	6 00	3,000	10 50	2,100	500	5 50	3,300	1,077,790
6	Barnard & Gowan, Chicago, Ill.	F. W. Breckenridge, H. W. Dodge, Chicago, Ill.	8 00	4,000	10 00	2,000	1,000	5 00	3,000	1,353,000
7	John Cooper, Mt. Vernon, Ohio	Charles Cooper, G. A. Jones, Mt. Vernon, Ohio.	4 00	2,000	5 00	1,000	400	4 00	2,400	1,028,410
8	Willard Johnson, Fulton, N. Y.	Dervois DeWolf, W. S. Nelson, Fulton, N. Y.	5 00	2,500	5 00	1,000	1,500	3 00	1,800	1,129,150
9	John E. Harroun, Fulton, N. Y.	F. D. Van Wagenen, Elliott Harroun, Fulton, N. Y.	5 00	2,500	6 00	1,200	2,000	4 00	2,400	1,213,550
10	Reynolds, Saulpaugh & Co., Rock Island, Ill.	Ira M. Gifford, Davenport, Iowa, James Ward, St. Louis, Mo.	11 00	5,500	8 00	1,600	13,500	10 00	6,000	1,715,350
11	Norris G. Dodge, Cleveland, Ohio	Charles Pardee, Henry I. Hubbard, Skaneateles, N. Y.	3 50	1,750	10 00	2,000	900	2 75	1,650	1,175,520
12	William Lee & Co., Randolph, N. Y.	S. C. Walker, Harry Fox, Chicago, Ill.	7 00	3,500	7 00	1,400	1,500	5 00	3,000	1,022,750
13	Dodge, Lord & Co., Cincinnati, Ohio	Orlando Smith, Benjamin B. Frost, Chillicothe, Ohio.	13 00	6,500	15 00	3,000	....	......	....	1,172,200
14	John L. Zwart, Keokuk, Iowa‡	John McCune, George Williams, Keokuk, Iowa.	4 50	2,250	3 50	700	3,000	4 00	2,400	968,095
15	George Williams, Keokuk, Iowa§	John McCune, John L. Zwart, Keokuk, Iowa.	12 50	6,250	12 50	2,500	2,500	3 00	1,800	997,950
	Patrick Gibbons & Co., Keokuk, Iowa.‖	John D. Thurmond, Isaac N. Armentrout, Keokuk, Iowa.	5 50	2,750	15 00	3,000	500	6 00	3,500	906,885

I certify that the foregoing abstract is correct.

J. H. WILSON,
Lt. Col. and Brt. Maj. Gen. U. S. Army.

UNITED STATES ENGINEER OFFICE, *Keokuk, Iowa, June* 30, 1869.

C. *Abstract of proposals received at the United States Engineer Office at Keokuk, Iowa, May 31, 1869, for furnishing stone for the three locks of the canal for the improvement of the Des Moines Rapids of the Mississippi River, viz: Guard, Middle, and Lower locks.*

Number.	Name and residence of bidders.	Name and residence of guarantors.	Certified to by—	GUARD LOCK. Face stone, 3,323 cubic yards.		Backing stone 4,660 cubic yards.		Rubble stone for vertical or battered wall, 6,300 cubic yards.		Rubble stone for slope wall, 770 cubic yards.		Aggregate.
				Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Amount.
1	Charles J. DeGraw, Fulton, Oswego County, N. Y.	W. S. Nelson J. H. Townsend, Fulton, Oswego County, N. Y.	George Sawyer	$10 00	$33, 230 00	$6 00	$27, 960 00	$5 00	$31, 500 00	$3 00	$2, 310 00	$95, 000 00
2	Philip K. Allen, D. Judson Jenné, Moline, Rock Island County, Ill.	Elliott Harroun, J. E. Harroun, Fulton, Oswego County, N. Y.	Daniel C. Jenné......	16 00	53, 168 00	10 00	46, 600 00	8 00	50, 400 00	4 00	3, 080 00	153, 248 00
3	Frederick D. Van Wagenen, Fulton, Oswego County, N. Y.	Charles G. Case, Samuel L. Case, Fulton, Oswego County, N. Y.	....	13 00	43, 199 00	8 00	37, 280 00	6 00	37, 800 00	5 00	3, 850 00	122, 129 00
4	W. Steel, Thomas Fletcher, Keokuk, Iowa.	Charles Hubbell, David G. Lowry, Keokuk, Iowa.	W. W. Belknap, Keokuk, Iowa.	18 75	62, 306 25	12 00	55, 920 00	8 00	50, 400 00	5 00	3, 850 00	172, 476 25
5	John McNamara, James McNamara, Keokuk, Iowa.	Alexander Barclay, R. H. Wymarr, Keokuk, Iowa.	W. W. Belknap, Keokuk, Iowa.	12 00	39, 876 00	11 00	51, 260 00	10 00	63, 000 00	5 00	3, 850 00	159, 986 00
6	John L. Zwart, Keokuk, Iowa	John McCune, James E. Burke, Keokuk, Iowa.	W. W. Belknap, Keokuk, Iowa.	15 15	50, 343 45	6 40	29, 824 00	2 60	16, 380 00	1 50	1, 155 00	97, 702 45

C.—*Abstract of proposals received at the United States Engineer Office at Keokuk, Iowa, &c.*—Continued.

Number.	Name and residence of bidders.	Name and residence of guarantors.	Certified to by—	MIDDLE LOCK. Face stone, 3,050 cubic yards.		Backing stone, 5,606 cubic yards		Rubble stone for vertical or battered wall, 3,080 cubic yards.		Rubble stone for slope wall, 200 cubic yards.		Aggregate.
				Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Amount.
1	Charles J. DeGraw, Fulton, Oswego County, N. Y.	W. S. Nelson, J. H. Townsend, Fulton, Oswego County, N. Y.	George Sawyer	$10 00	$30, 500 00	$7 00	$39, 242 00	$5 00	$15, 400 00	$3 00	$600 00	$85, 742 00
2	Philip K. Allen, D. Judson Jenné, Moline, Rock Island County, Ill.	Elliott Harroun, J. E. Harroun, Fulton, Oswego County, N. Y.	Daniel C. Jenné......	17 00	51, 850 00	10 00	56, 060 00	8 00	24, 640 00	4 00	800 00	133, 350 00
3	Frederick D. Van Wagenen, Fulton, Oswego County, N. Y.	Charles G. Case, Samuel L. Case, Fulton, Oswego County, N. Y.	....	14 00	42, 700 00	9 00	50, 454 00	7 00	21, 560 00	5 00	1, 000 00	115, 714 00
4	W. Steel, Thomas Fletcher, Keokuk, Iowa.	Charles Hubbell, David G. Lowry, Keokuk, Iowa.	W. W. Belknap, Keokuk, Iowa.	18 00	54, 900 00	12 00	67, 272 00	8 00	24, 640 00	5 00	1, 000 00	147, 812 00
5	John McNamara, James McNamara, Keokuk, Iowa.	Alexander Barclay, R. H. Wymarr, Keokuk, Iowa.	W. W. Belknap, Keokuk, Iowa.	11 50	35, 075 00	10 50	58, 863 00	9 50	29, 260 00	5 00	1, 000 00	124, 198 00
6	John L. Zwart, Keokuk, Iowa ...	John McCune, James E. Burke, Keokuk, Iowa.	W. W. Belknap, Keokuk, Iowa.	15 15	46, 207 50	6 40	35, 878 40	2 60	8, 008 00	1 50	300 00	90, 393 90

C.—*Abstract of proposals received at the United States Engineer Office at Keokuk, Iowa, &c.*—Continued.

Number.	Name and residence of bidders.	Name and residence of guarant's.	Certified to by—	Lower lock. Face stone, 3,530 cubic yards. Rate.	Face stone Amount.	Backing stone 6,912 cubic yards. Rate.	Backing stone Amount.	Rubble stone for vertical or battered wall, 8,850 cubic yards. Rate.	Rubble stone Amount.	Rubble stone for slope wall, 900 cubic yds. R'te.	Rubble stone for slope wall Amou't.	Aggregate. Amount.	Grand aggregate of the three locks. Amount.
1	Charles J. DeGraw, Fulton, Oswego County, N. Y.	W. S. Nelson, J. H. Townsend, Fulton, Oswego County, N. Y.	George Sawyer.....	$11 00	$38, 830 00	$7 00	$48, 384 00	$6 00	$53, 100 00	$3 00	$2, 700	$143, 014 00	$323, 756 00
2	Philip K. Allen, D. Judson, Jenné, Moline, Rock Island County, Ill.	Elliott Harroun, J. E. Harroun, Fulton, Oswego County, N. Y.	Daniel C. Jenné....	18 15	63, 540 00	10 50	72, 576 00	8 00	70, 800 00	4 00	3, 600	210, 516 00	497, 114 00
3	Frederick D. Van Wagenen, Fulton, Oswego County, N. Y.	Charles G. Case, Samuel L. Case, Fulton, Oswego County, N. Y.	....	15 00	52, 950 00	10 00	69, 120 00	7 00	61, 950 00	5 00	4, 500	188, 520 00	426, 303 00
4	W. Steel, Thomas Fletcher, Keokuk, Iowa.	Charles Hubbell, David G. Lowry, Keokuk, Iowa.	W. W. Belknap, Keokuk, Iowa.	18 15	66, 187 50	12 00	82, 944 00	8 00	70, 800 00	5 00	4, 500	224, 431 50	544, 719 75
5	John McNamara, Jas. McNamara, Keokuk, Iowa.	Alex. Barclay, R. H. Wymarr, Keokuk, Iowa.	W. W. Belknap, Keokuk, Iowa.	14 00	49, 420 00	12 00	82, 944 00	11 00	97, 350 00	6 00	5, 400	235, 114 00	517, 298 00
6	John L. Zwart, Keokuk, Iowa.	John McCune, Jas. E. Burke, Keokuk, Iowa.	W. W. Belknap, Keokuk, Iowa.	15 15	53, 479 50	6 40	44, 236 80	2 60	33, 010 00	1 50	1, 350	122, 076 30	310, 172 65

REMARKS.—1. Did not comply with, and does not fulfill the requirements of the advertisement, and could not deliver the stone for the prices specified. (See letter of transmittal.)

3. Best bid for the rock required, face and backing principally, but too high.

6. Unreliable and incompetent. (See statement of H. Scott Howell, attorney-at-law, letter of transmittal.)

I certify that the foregoing abstract is correct.

J. H. WILSON,
Lieut. Col. and Bvt. Maj. Gen. United States Army.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, June 30, 1869.

D.—*Abstract of contracts entered into during the fiscal year ending June* 30, 1869, *for the improvement of the Des Moines Rapids of the Mississippi River.*

Number.	Date.	Name and residence of contractors.	Name and residence of bondsmen.	For what purpose.	Amount.	Remarks.
1	Aug. 14, 1868..	James Clark, Utica, Ill	John L. Clark, Henry F. Clark, Utica, Illinois.	3,325 casks cement for lower lock.	$9,000 00	
2	Aug. 15, 1868..	Ephraim Owen, Albany, N. Y........	James McDonald, Albany, N. Y.; John McDonald, Amsterdam, N. Y.	Labor, constructing the lower lock.	220,000 00	
3	Aug. 28, 1868..	Charles E. Tobie, Utica, N. Y........	Peter Tobie, Utica, N. Y.; Remy Glatt, New Hartford, N. Y.	Stone for the lower lock.....	66,000 00	Abandoned May 8, 1869.
4	Dec. 4, 1868..	James J. Dull, Harrisburg, Pa........	W. W. Wiley, Lancaster, Pa.; George Williams, Albert L. Connable, A. Hosmer, Guy Wells, Keokuk, Iowa.	Constructing embankment wall and excavation of prism of canal.	500,000 00	
5	June 10, 1869..	Charles G. Case, Frederick D. Van Wagenen, Fulton, N. Y.	Sands N. Kenyon, Thomas W. Chesebro, Fulton, N. Y.	Stone for guard, middle, and lower locks.	200,000 00	

I certify that the foregoing abstract is correct.

J. H. WILSON,
Lieut. Col. and Bvt. Maj. Gen. United States Army.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, June 30, 1869.

E.—*Report of Brevet Major Charles D. Allen, captain Corps of Engineers.*

UNITED STATES ENGINEER OFFICE,
Rock Island, Illinois, July 7, 1869.

GENERAL: I have the honor to submit the following report of the engineer operations under my charge for the year ending June 30, 1869, pertaining to the improvement of the Rock Island Rapids of the Mississippi River:

My last annual report, dated Davenport, Iowa, June 30, 1868, contained a synopsis of field and office work for the year, and showed the approximate completion of the channel then being excavated at Duck Creek Chain, about six and a half miles above this city; the commencement of the coffer-dam for the improvement of Moline Chain, two and a half miles above this place; and preparations for the commencement of the large coffer-dam at Sycamore Chain; also a description of chisel boats and dredges used, and the construction and method of putting in the dams. Up to that time there had been excavated and removed from the bed of the river at Duck Creek Chain, 6,898.66 cubic yards of rock, of which 5,183.80 yards were removed by means of the coffer-dam, and 1,714.86 yards had been broken up by means of the Osgood chisels, and removed by the dredges. Of the Moline coffer-dam, the breakwater at the head had been completed, and a few feet of the head of the dam built.

The chisel-work was kept up steadily at Duck Creek Chain throughout the season, it being necessary to break up, by this method, an irregular mass of rock about 1,500 feet in length by 200 feet in width. As rapidly as the rock was broken sufficiently fine by the chisels, it was taken up by the dredges, and removed either to the shore, or to deep holes and pockets in the immediate vicinity of the work. The excavation had been completed within the coffer-dam as stated, but the dam was left in for the season to facilitate the working of the chisels and dredges, by forming a breakwater above the scene of operations, giving partial slackwater below the dam, and also serving to protect the boats from steamers and other floating bodies.

The dredges were taken off during the month of July, in order to use them for furnishing puddling for the coffer-dam in process of construction at Moline Chain, and during the succeeding fall they were again taken off for a short time to aid in constructing the large dam at Sycamore Chain. One of them was afterward returned to the work. By the 5th of December, the cold had become so intense, and the ice was running so freely in the river, that the contractors hauled their dredges and chisels off the work, and laid them up for the winter. I did not consider them authorized to do this without my consent, and notwithstanding the running ice, I forced them out again into the stream, and kept them there until the 22d of the month, when, it being impossible to work longer, they were finally taken into winter quarters. Both in getting them out and returning them, ice saws and axes had to be used in order to cut channels for the boats, through the gorges and fields of ice. The work was resumed at this chain in April of the succeeding year, and the coffer-dam, cribs, and piles of loose stone finally removed and the channel reported clear.

The following quantities of rock were estimated as broken and dredged up, viz:

	Cubic yards.
August	506.25
September	673.99

	Cubic yards.
October	672.13
November	967.08
December	568.12
Total by chisels and dredges	3,387.57

Days' labor at Duck Creek Chain, reduced to number of days' services:

	Days.
Superintendents	173
Foremen	194
Engineers	343
Blacksmiths	156
Carpenters	120
Laborers	1,126
Total	2,112

With two dredges, two chisels, and two flats.

Cost per cubic yard of excavating rock by means of chisels and dredges:

Actual cost per yard	$2 52
Royalty on use of patent chisel	50
Premium arising from interest on capital invested, depreciation of tools, &c	3 46
Total cost per yard	6 48

Sixty strokes of the chisel are necessary to break one yard of rock.

The accompanying small map of this chain will show the extent of the work.

By the 30th of July the coffer-dam on Moline Chain had been finished and connected with the stone dam at the head of Rock Island, by a bridge built on stone cribs, five hundred feet in length. The coffer-dam (see tracing) had an average cross section of 9 by 9 feet, and a development of 2,645 linear feet. Placed upon a rock bottom and in a current of 6.3 feet per second, extraordinary pains had to be taken in its construction, and in protecting it by means of cribs on the outside. To further secure it from the blows of rafts or logs, booms were constructed on the up-stream side, and the line of cribs at its head extended into the stream from twenty feet to thirty feet on either side.

The work was considerably delayed from the frequent collisions of steamers, which, in trying to ascend the chain, were drawn into the eddy at the foot of the dam, and thence swung against the work itself. Sections of the coffer work were broken through in this way no less than six times, entailing loss upon the contractors, and delaying the work.

Remonstrances failing, I directed cribs filled with stone to be sunk, and piles of stone to be placed where the dam was likely to be struck by boats, and then notified the steamboat men. After this no accidents of this nature occurred. The dam inclosed six acres, averaging 260 feet in width and 950 feet in length.

By the 15th of August the inclosed area was finally cleared of water by means of the pumps, and a close topographical survey of the rock bottom was made. An examination showed the lime rock to be much more regular in its formation and layers than that worked at Duck

Creek Chain the preceding year. A large number of granite boulders were found scattered over the surface of the rock, which had undoubtedly been deposited there by the fields of ice as they moved down in the spring. Some of these were of large size, sufficiently so to cause the destruction of any vessel striking against them, and it is singular that they were never reported. These boulders are liable to be deposited at any time, and after the completion of the work, if any such should be the cause of damage to vessels, it must not be attributed to the engineering of the work. Provision should be made for the immediate removal of boulders as often as they are reported on any of the chains, and for this purpose and for others it seems to me that the establishment of a government dredge would, in the end, be found economical.

The natural surface slope on this chain was found to be thirty-five hundredths of a foot upon one thousand feet. It was decided to channel through the rock, making the "cut" two hundred feet wide, and giving the bottom a slope parallel to the slope of the surface of the water. By giving the bottom a flatter slope than this, the velocity of the current over the main portion of the chain would have been lessened to the advantage of steamers ascending this portion; but the back-water produced in consequence would have caused a heavier fall at the foot of the chain, this resulting velocity of current being calculated at nearly eight feet per second. All circumstances considered, it was thought that by simply deepening the main channel, as above stated, the best results would be obtained.

In making the improvement here, as upon the other chains, the object has been to so arrange the "cuts" as to preserve, if possible, the existing regimen of the river at the respective points. The three objects kept steadily in view have been to get the line of least cutting, to keep the axis of the "cut" in the direction of the current at low water, and not to increase the velocity materially.

The sides of the channel received a slope of one upon two.

The contractors at first limited themselves to cutting a narrow channel throughout the length of the area, for the double purpose of getting a "face," and for the complete drainage of the inclosure. The drilling was done by hand, and the blasting by means of safety fuse. The proportion of rock blasted to the powder used was one yard to the pound. The excavated rock was removed to the stone dam at the head of Rock Island, by means of current and rope ferries, and delivered to General Rodman for the purpose of aiding in the construction of the dam being built by the Ordnance Department.

An equivalent of 26,000 yards of loose rock was thus delivered. The work continued without material interruption until the early part of November, when, in consequence of heavy rises in the river, the dam was flooded. About the 11th of December the pumping was again commenced and the dam emptied; but, in consequence of the heavy accumulation of ice at the head of the dam, and the destruction by ice of the bridge connecting the island with the dam, but little could be done toward removing the rest of the rock as desired. The broken rock was, however, removed from the interior of the dam and deposited in the river near the south side of the dam, to be dredged up the following spring.

In April, 1869, the dredges were set at work again, and the loose rock and a portion of the coffer removed. The chisel-boats were also set at work to break up the patch of rock at the head of the chain, which had not been included in the coffer-dam. By the last of June this work was

nearly accomplished, but, in consequence of extreme high water, the boats had to be drawn off again.

Total quantity of rock excavated and removed from this chain to the 30th day of June, 1869, was 16,958.41 solid yards.

Estimated cost of the coffer-dam, $19,926 75; the average cost per lineal foot being $7 50.

The filling was brought in flats a distance of two and a half miles.

Days' service at Moline Chain.

Building dam:

	Days.
Superintendents	53
Foremen	287
Engineers (steam)	47
Laborers	1,569
Total	1,956

The men employed in building the dam were skilled workmen and commanded about sixty per cent. more than other laborers.

In excavating and removing rock:

	Days' service.
Superintendents	181
Foremen	1,126
Engineers (steam)	309
Blacksmiths	269
Carpenters	145
Laborers, (including quarrymen, drillers, wheelers, &c.)	16,977
Total	19,007

The engineers were engaged principally in running the pumps, and the carpenters and blacksmiths in repairing tools.

Recapitulation:

	Days service.
Superintendents	234
Foremen	1,413
Engineers	356
Blacksmiths	269
Carpenters	145
Laborers, (including quarrymen, drillers, wheelers, &c.)	18,546
Aggregate for this chain	20,963

The greatest quantity of rock removed during any month was as follows:

	Cubic yards.
In October, 1868, at Moline Chain	6,299.27
In January, 1869, at Sycamore Chain	10,786

The average amount of rock removed and excavated, per day, for each man, was one yard.

The small map sent herewith will show the extent of the excavation.

Early in the summer preparations were made for excavating a channel through Sycamore Chain, thirteen miles above Davenport, as soon as the stage of water would admit of operations.

The chain had been thoroughly examined and sounded during the summer of 1867, and a very complete hydrographic chart had been obtained.

The soundings were very numerous, about 25,000 having been made, by the method explained in my former report, reduced to low-water reference and platted.

The soundings were distributed over an area of about 3,000 feet by 1,500 feet, and the contour lines of the bottom very accurately delineated, enabling a close estimate of the amount of rock to be excavated, to be made.

This survey was afterward verified by a minute survey of the bottom, after it had been laid bare, and it was found to tally very closely.

The chain is 2,700 feet in length, with a surface slope of 2 to 76, and a surface current varying from 6.5 feet per second to 3.5 feet per second.

The water had worn for itself a very irregular channel through the rock, its axis forming a sort of long "S." The main channel was intersected by several smaller channels and chutes, the water rushing through the latter with considerable velocity; the effect of which, conjointly with the current of the main channel, was to carry vessels out of their course, and either force them against the sharp, projecting rock on either side of the channel, or to force them into the small chutes, where they frequently remained for days, if not totally wrecked. During seasons of high water, no difficulty had been experienced at this chain, or in fact at any of the chains, other than the difficulty of stemming the current, there being then plenty of water for the passage of the largest steamers on the Upper Mississippi River. During the season of low water, the passage of boats at Sycamore Chain had always been attended with danger, and at the lowest stages of water its passage was impossible.

About six hundred feet below the head of the chain, the rock rose abruptly from the bottom, forming a sort of bridge, connecting the walls of rock on each side of the channel, over which, at lowest water, there was scarcely a foot depth.

Below this there was a small whirlpool or "boil," as it was called by boatmen, caused by the water rising over this bridge, as in the case of a submerged dam.

The width of the natural channel over this bridge at low water being not more than thirty feet, and occurring at the head of the channel, it is a matter of wonder how boats had ever managed to get over it even at middle stages of the river.

In fact, an examination of the bottom showed many points and patches of rock polished to a marble smoothness by the keels of boats.

Below the bridge the channel gradually increased in width, not, however, exceeding one hundred and eighty feet, until at the lower end it abruptly narrowed, with an increase of surface velocity.

Immediately above and below the chain was deep water.

Early in July the contractors commenced the delivery of lumber and iron, nails, spikes, &c., for the construction of the dam, which, after a close examination of the bottom of the chain, was calculated to inclose the entire portion of the chain on the Illinois side of the river, com-

mencing at the head, and jutting out from the Illinois shore into the river about 1,100 feet, thence down stream about 2,600 feet, and thence to the shore again. It was a matter of doubt at first, in such a current, and with an irregular bottom, the rock bordering the channel and chutes, in many cases shelving under, whether the dam could be carried across the chutes and main channel, in from sixteen to eighteen feet of water.

However, there was no alternative; the chain had to be inclosed by a coffer-dam, there being no other way of reaching and working the rock.

By the 8th of August the materials had all been delivered; dredges, steamers, flats, &c., were on hand, and the coffer-dam was commenced. The puddling was raised by the dredges, from the mouths of small streams, sloughs, &c., and was conveyed in flats to the place of deposit. Most of the puddling was brought from points a mile distant, and over; none of it being brought less than three-fourths of a mile.

The construction of the dam was preceded by the erection of a break-water, a few feet above its head line, which was built parallel to the dam, and generally about 150 feet in advance of it. Its purpose, as in the case of the dams at Moline and Duck Creek Chains, was to protect the work from injury, and to give still water below it, to render the moving of boats and rafts of lumber easier.

The line of cribs and breakwater extended down stream about two-thirds the length of the dam, and four-fifths along its head.

By the middle of September the head line had been extended 1,097 feet from the Illinois shore, and turned down stream.

It was then extended down stream 2,662 feet, and then turned in shore for 661 feet, the whole being finished by the 14th of November.

In filling the last 100 feet, this portion of the dam careened outward, owing to the puddling having been thrown in too much on one side. This was soon righted again, and toward the end of November the entire dam was closed, and the weak points strengthened by loose stone and timber braces on the inside, and by embankments of loose earth on the outside. Two centrifugal pumps, one of 12-inch pipe, and the other of 9-inch pipe, were placed at the lower end, preparatory to clearing the area of water.

The rise in the river precluded any attempt at pumping, until the 12th of December, when both pumps were set in operation. The discharge of the larger one averaged 522 cubic feet per minute; that of the smaller 480 cubic feet. The engines were of 25 and 12 horse-power, respectively. By the 26th the rock bottom was sufficiently exposed to enable its character to be determined. The rock is magnesian limestone, variable in structure and hardness, and dipping 15° to the northeast, and stratified.

The ice, which was over a foot in thickness, settled with the water, as the latter was pumped out, until it rested upon the solid rock bottom.

The work of stripping the ice commenced, and in a few days was sufficiently advanced to enable a survey of the bottom to be undertaken. The survey was very carefully made, and compared favorably with the previous surveys. Base lines, triangulated from the primary bases, on the Iowa shore, were laid out on the ice, and the curves of excavation previously decided upon in the office, laid out, by means of calculated ordinates and abscissas.

The natural channel was of itself upon an easy curve, except at one or two points, (see sketch and tracing,) and it was found, after calcula-

tion and comparison of various routes, to be more economical and to subserve the object in view better to deepen and widen this channel so as to render the curve easier, and at the same time to follow the line of the old channel as nearly as possible.

The essential curve of this new channel would not, by this plan, be more than one degree. Assuming that the fall of the surface of water would be the same after excavation of the channel as before, a curve would offer an advantage over a straight "cut" by giving a longer base to the same head of water, and thus would lessen the surface velocity. Moreover, the advantage of this line over any other, in the matter of economy, (it being cheaper by at least $100,000,) was so decided that the preference hardly admitted of an argument.

The bottom of the "cut" was to have the same slope as the surface of the water, and the sides a slope of one-half. The work, from its importance and extent, and its bearing upon the interests of navigation, attracted particular attention throughout this section of the country, and the season of navigation being over, river men had ample time to visit the work and examine into its details, and see what they had been running over for years. The majority of them seemed to comprehend and be satisfied with the work which was to benefit them, but a few, exercising their talents and undoubted prerogatives, took every occasion to find fault with it, and finally circulated a petition to be forwarded to Washington, praying for a change of line; to make the excavation upon a straight line instead of a curve, the only effect of which was to force me to make some additional examinations above and below the chain, proving what had already been proven before, viz., that the line decided upon in your office was the most economical, as well as the best in every sense. The only benefit which could have resulted from this desired change would have accrued to the contractors, who doubtless would not have been dissatisfied with it, although I have been assured that they had no participation in the movement.

Most of the river pilots are men possessed of but little knowledge beyond that required in turning the wheel, and their obstinacy in refusing to recognize and take advantage of good channels cut for them has been the experience of more than one engineer engaged in improving rivers. The rapids pilots in particular, who may lose employment by the improvement, seemed to be the most hostile.

The work upon this chain had been, until this time, under the immediate charge of Mr. A. Livermore, civil engineer and assistant. Mr. Livermore was relieved toward the close of December, and I transferred its immediate superintendence to Lieutenant Hoffman, who remained upon the work until its completion in February.

The contractors commenced the work of excavation about the 27th of December, and continued it without any delay until the 12th of February, when water was let into the dam. The average number of men employed daily during the month of January, was four hundred and fifty.

The total excavation from the area within the dam was 15,804.05 solid yards. The development of the dam was about four thousand six hundred linear feet; shore line of dam two thousand four hundred linear feet additional.

Average cross section ten feet by ten feet. Area inclosed by the dam about forty-five acres, or 1,844,000 square feet. Cost of dam, including value of floating property employed in its construction, $98,126 84. Average cost per running foot, $21 30. Cost of rock excavation, (exclusive of dam,) $56,077. Total cost to contractors of excavation, including building dam, dredging it up, and removing cribs, and allowing for depreciation of floating property, $144,365 84.

Force employed at Sycamore Chain, reduced to days' service.

In building dam and preparing it for the work of excavation:

	Days' service.
Superintendents	270
Foremen	623
Engineers (steam)	275
Blacksmiths	166
Carpenters	306
Laborers	5,790
Total	6,430

In stripping ice, preparatory to excavating:

	Days' service.
Superintendents	12
Foremen	38
Engineers	24
Blacksmiths	12
Carpenters	7
Laborers	1,099
Total	1,192

The engineers were employed in running the pumps to keep the area clear of water; blacksmiths in sharpening tools; carpenters in repairing tools, &c. The ice was stripped from the rock-bed, as shown in my report.

In excavating rock:

	Days' service.
Superintendents	66
Foremen	432
Engineers	132
Blacksmiths	124
Carpenters	87
Teams and teamsters	259
Laborers, quarrymen, wheelers, &c	13,597
Total	14,697

Upon the entire work, then, including building dams, stripping ice, and excavating rock, we have—

	Days' service.
Superintendents	348
Foremen	1,093
Engineers	431
Blacksmiths	302
Carpenters	400
Teams and teamsters	259
Laborers, quarrymen, wheelers, &c	19,486
Of all kinds	22,319

700,000 feet (board measure) of lumber used in construction;
3,800 yards of stone for cribs;
14,000 yards of puddling, of which 750 flat-boat loads were brought from distances averaging one mile.

The remainder of the filling was wheeled from the shore, and used simply to give additional weight to the structure. The original intention had been to extend the dam three hundred feet further down, but as the contractors feared that they would be unable to close it before the advent of extreme cold weather, if they were forced to go this distance, and as they then had a great deal of risk upon their hands, I was willing to permit them to leave it over for the present season, upon their assurance that they would put in another dam below, and resting upon the large one, as soon as the work could be resumed in the spring.

This new dam was commenced in the March following, and finished in April, but, on account of the spring rise, it could not be pumped out before the early part of June, when the river lowered sufficiently to enable them to do so with safety.

About four hundred yards of rock were taken out of this inclosure, when, the river rising again, work had to be temporarily suspended.

Days' service in building small dam at Sycamore Chain, putting up pumps and preparing it for the work of excavation.

	Days' service.
Superintendents	77
Foremen	77
Engineers (steam)	55
Blacksmiths	77
Carpenters	77
Laborers	525
Total	898

and one steamer, one dredge, and two flats.

Six days' work in excavating rock from the area, up to and including June 30, 1869.

	Days' service.
Superintendent	6
Foremen	24
Engineers (steam)	12
Blacksmiths	7
Carpenters	6
Laborers	370
Total	425

RECAPITULATION.

	Days' service.
Superintendents	83
Foremen	101
Engineers	77
Blacksmiths	84
Carpenters	83
Laborers	895
Aggregate of work on small dam	1,323

Total amount of rock excavated from the bed of the river to date.

	Days' service.
At Moline Chain	16,958.41
At Duck Creek	9,982.30
At Sycamore Chain	16,204.05
In all	43,144.76

Grand aggregate of all hands employed in building dams, chiselling, dredging, blasting, quarrying, and wheeling for the year ending June 30, 1869.

	Cubic yards.
Moline Chain	20,963
Duck Creek Chain	2,112
Sycamore Chain	23,642
Grand total	46,717

The improvement of the channel through Campbell's Chain was contemplated this season, but in consequence of there being three works already in progress, and the probability that the construction of the necessary coffer-work would be carried into the winter, thus endangering its safety, and the lack of necessary funds to push the work as desired, it was abandoned for the season. From the nature of the rock bottom upon the various chains, their diversity of shape, the composition, dip, and stratification of the rock blasting, to a theoretical plane has been very difficult of attainment.

The proportionate charges of powder found by experience upon one chain to be correct, could not be relied upon for another.

The blasts threw off more or less from each particular point than was actually necessary or desirable, in order to give the depth sought, viz: four feet at lowest water, the depth required at all the chains.

Take the case of a horizontal stratum two feet in thickness, and suppose that a depth of one foot and eight inches below its upper surface is to be reached. The drill, for precaution, penetrates only to one or two inches of the depth required; the blast will throw out the rock to the depth of its bed, and the entire stratum must be taken out.

In cases where the rock has a decided dip, the drill must penetrate to the depth of the theoretical plane of excavation, and the effect of the blast is to throw out a large prism of rock below the theoretical plane, and to leave in a prism above it which must be drilled and blasted again, repeating the error, if it may be called so. The extra rock thus thrown out by the blasts must necessarily be removed, unless it chances to be broken into small fragments, when it may be left where it falls, provided its surface is not above the plane of the bottom established. This is seldom the case, however, and the masses must be broken by sledges into pieces suitable for handling, and then either wheeled away, or drawn by means of stone boats. In either case expense occurs in the handling of it, and as this is something that is unavoidable, the contractors claimed compensation for it. In working the chain at Duck Creek and Moline, notwithstanding the great irregularity of the bottom of the former, the proportion of over-excavation to the desired excavation was very small; at Moline Chain it was five per cent. of nearly 17,000 yards,

showing not only faithful work upon the part of the contractors, but also faithfulness upon the part of my assistants in keeping the excavation so close to the original estimates. Work of this nature cannot be carried on over such large areas, and the excavation kept to close limits, unless the hammer and chisel are used, which of course is out of the question. A close examination of the bottom, as shown at Sycamore Chain, its great irregularity of surface, and the dip of the strata, convinced me that it would be impossible, by the closest attention to blasting, to prevent over excavation. I desired Colonel Ulffers, civil engineer and assistant, who is a professional geologist, to take a geological survey, and to report what in his opinion would be the necessary amount of over-excavation in getting out the estimated quantity of rock.

He reported an average extra depth of sixty-six hundredths of a foot, which, multiplied by the area worked over, would give nearly 5,000 yards additional. There had always been a tacit understanding, from the time the work was commenced, that the necessary extra excavation would be considered in your office, leaving the question of compensation open, to be decided by superior authority. The surveys at the conclusion of the work at Sycamore Chain showed that the average depth to which the blasts had been carried below the theoretical plane was 0.926 feet, but as a large proportion of this broken rock was left in, and spread over the area in small fragments, it could not all be taken into consideration. The quantity of solid rock actually removed below bottom of excavation was 3,533.25 yards, and the actual cost per yard to the contractors for this portion was estimated, from the best information in the possession of this office, to be $8 79.

The contractors claimed payment for this at contract prices, viz: $13 per yard, basing their claims upon the text of the contract of June 28, 1867, drawn up before I was connected with the work.

It says: * * * "That the said parties of the second part shall furnish all the boats, machinery, and materials of every sort required, which shall be of good and sound quality, and perform all the labor necessary to excavate and remove from the bottom of the Mississippi River, at such place or places on the upper or Rock Island Rapids of the Mississippi River as may be designated by the engineer in charge of the work, all rock or other material necessary to make a continuous channel through said rapids." * * * * *

Further on it says that the channel shall not be less than four feet deep in the lowest stages of the river.

The claim turned upon the word "necessary;" the contractors contending that as the rock was necessarily removed in order to give the channel required, and that as the depth to which they blasted was unavoidable in order to give even a less depth of channel, they were entitled to full price per yard. They also referred to the paragraph in Colonel Hains's report of the survey of the rapids in 1866, and the accompanying estimate of quantities to be removed, in which the words occur: * * * * "It may appear at the first glance that the percentage I have added for contingencies in excavating is rather large, but after a careful consideration I can only say that I am convinced it is not.

"Experience has taught us that in excavating rock at the lower rapids, the cost is materially increased by the more or less favorable seasons for working, and, moreover, the rock being in strata of various thicknesses, if, in deepening a part to four feet, we should come to a stratum two feet thick, the entire stratum must be taken out."

I have made this extract as it seems necessary to a full discussion of the subject.

The evident meaning is that if the upper surface of the stratum should be a few inches above the required depth, and the remainder of the stratum below, the whole must be taken out. I think the report has been misprinted, and that it should read: "If in deepening a part two feet we should come to a stratum four feet thick, the entire stratum must be taken out." Still the meaning is evidently the same in both. As soon as the estimates of work done were made I submitted the question with a statement to your office. By you it was submitted to the department, and then to the Secretary of War, and returned with the approval of your recommendation to pay to the contractors the cost to them of removing the rock. I have not inserted any of the correspondence or figures, as you have them in your office.

The field work during the season has been extensive, consisting in the observations of currents, locating buoys for the erection of dams, triangulating and establishing base lines for laying out lines of excavation, dams, &c., and in taking additional topography of the country bordering the rapids.

Additional soundings have also been made upon the portion of Duck Creek Chain worked over by the chisel boats, the soundings reduced, and new maps made, showing the condition of the chain at that time, in all about six thousand soundings. St. Louis Chain was also thoroughly sounded in November, by means of a steamer and attached skiffs, and twelve thousand soundings taken, reduced, and platted. About five thousand soundings were also made in January, upon the portion of the river immediately above the coffer-dam at Sycamore Chain, and added to the charts of that chain.

The maps finished in the office have comprised sounding and contour maps of the different chains, a general map of the rapids, small reduced maps of the chains, and working sheets and sketches.

The draughting has been mainly done by assistants C. J. Pauli and J. H. Harlow.

Water gauges have been established at convenient points, and their daily readings recorded.

The summer, fall, and winter were generally favorable for work, but this spring has been the reverse, heavy rains and high water prevailing.

The proportions of powder used to rock blasted have been as follows:

At Duck Creek Chain, seven-thirteenths pounds of powder to one yard of rock.

At Moline Chain, one pound of powder to one yard of rock.

At Sycamore Chain, two pounds of powder to one yard of rock.

The excess of powder at this latter chain is in part due to the work having been done in the winter, the broken rock being frequently frozen together during the night, and the conglomerate mass having to be blasted again in the morning.

The method of constructing and putting in the dams has been the same as described in my last report, viz: First, a line of cribs sunk above the head line of the dam and connected with each other by heavy timbers, against which planks were rested on the up-stream side, their lower ends abutting against the bottom of the river. The planks were as close together as possible, and inclined at an angle of about forty-five degrees with the horizontal. A breakwater was thus formed, which, being extended some distance beyond either end of the head line of the coffer, gave comparatively still water below it.

The dam was then put in. The accompanying sketch will explain its construction.

The sheeting planks were chamfered at the lower end almost to the fineness of a pine shingle, and driven against the rock by blows of a mallet. The wood conforming to the shape of the bottom gave a water-tight joint. Tie-rods, of flat wrought iron, one and one-half inch by one-half inch, connected the upper and lower longitudinal pieces, both at the joints and midway between them. The string-pieces were generally of scantling, six by eight inches, and placed so that the dimension "six inches" should be vertical; two-inch plank were used for scantling.

The scantling used were generally insufficient in cross-section, and frequently broke between the tie-rods from the thrust of the filling.

In this, as in the general thickness of the dam, the contractors did not display the best of judgment. They generally made the cross-section of the dam "foot for foot," that is, one foot in thickness for one foot depth of water. This would not have been objectionable had they simply included the puddling in the thickness; but, on the contrary, they counted the thickness from "out to out," including, of course, the string-pieces and the sheeting plank. For depths under ten feet the strength of the dam was generally sufficient without bracing, but for depths over ten feet bracing occasionally failed. In running through depths of fifteen to sixteen feet, they were apt to keep the thickness of filling too low from mistaken notions of economy.

After several severe losses they finally concluded to adopt a rule for thickness compared with depth.

The rule given by Professor Mahan is easily followed, and where it has been observed in the construction of these coffer-dams, no disaster has occurred.

For filling, fine gravel, with a very small proportion of loam, has given the best results.

Gravel has one disadvantage to the strength of the dam itself—that of spreading like sand, or, as we say of water, "it seeks its level." The lower tie-rods and the washers have frequently been broken by the thrust of the filling as the water was pumped from the dam. Aside from this, the gravel, when fine and mixed with a small proportion of loam, makes the best filling of any used on these works. Unlike clay, if a leak occurs at any point within the body of the filling, or a small portion of it is washed out, the mass gradually settles and fills up the voids. Experience taught that the pumping should proceed slowly, in order that the filling might not settle too suddenly.

The leakage through the dams built and filled in this way was very slight, the pumps only working at times after once getting the water out. The line of cribs at Sycamore Chain served a double purpose. Put in, at first, to give partial slackwater below them and to act as a breakwater, they were utilized also in relieving the section of the coffer-dam, before they were thoroughly puddled and strengthened, from a portion of the pressure due to the head of water. The cribs were from three to six feet apart, and from fifteen to twenty feet from the dam, and in a line parallel to it. (See Figure 3, sheet No. 7.) As the dam was advanced, the head of water increased, owing to the contraction of the stream. The cribs were connected by timbers and planks spiked or rested upon them, the ends of the planks against the bottom of the river. As fast as a section of convenient length was thoroughly filled, a sort of plank dam was constructed (as shown in Figure 2, sheet No. 7) at its lower end. The surface of the water then above this latter dam and confined between

the coffer and the cribs, and planking being carried on ahead of the next section of the coffer, relieved the latter, during the process of its construction, of the weight of the prism of water, whose base was equal to the difference of level of the water from the head of the first reach to the foot of the section. Figure 1 explains itself; the red line is the slope of the water surface, commencing at the head of the dam. The blue shows the horizontal surface of the water in each reach. The first section bears an additional pressure owing to the water flowing around the head of the dam; the highest point of the surface of the backed-up water being near the junction of the dam with the shore.

This section of the dam was built much stronger than the others. The next section is relieved from the prism between the blue and the red line. So with the next section, C, D, &c. After the sections were constructed it was immaterial whether they were relieved of the pressure of the prism or not.

I inclose herewith the following sketches and tracings explanatory of the work done:

One small general map of the Rapids.

One special sketch of Moline Chain.

One special sketch of Sycamore Chain.

One special sketch of Duck Creek Chain.

One sketch showing plan, section, and elevation of coffer-dam for twelve feet of water.

One sketch showing the appearance of the coffer-dam and excavated channel at Sycamore Chain on the 12th of February.

One sheet showing process of putting in side line of dam at Sycamore Chain.

One large tracing showing coffer-dam and line of excavation at Sycamore Chain.

One large tracing, showing cross-profiles of bottom of Sycamore Chain.

One large tracing showing coffer-dam and line excavated at Moline Chain; also some photographs of work at Moline Chain.

It is proposed during the ensuing season to complete the small portion of work to be done at Sycamore Chain and to remove the dams and debris. Also to complete the removal of rock at the head of Moline Chain by means of the chisels and dredges; to remove a small piece of rock at the lower end of the chain, making the channel navigable at low water, but not completing it, and to remove the dam itself; also to begin and complete the excavation of the channel through Campbell's Chain about eight miles above this place.

The contractors have commenced getting out the lumber and iron for the dam to be put in at this chain, and, as soon as the river lowers sufficiently to admit of it, the dam will be laid out. The excavation here, it is estimated, will amount to about nine thousand yards, and the dam will inclose about one million three hundred thousand square feet, the upper and lower face jutting out from Campbell's Island into the stream, the shore forming one side of the inclosure.

The entire stretch of river between here and Le Claire (excluding the chains already sounded) will be thoroughly sounded and examined during the coming season.

The knowledge we now possess of the stretches of water between the chains is much too limited, and it is very desirable to know more of the nature of the channel.

The importance of complete and accurate soundings in this kind of work cannot be over-estimated. Even after the bottom has been laid

bare, the channel excavated, and the dams removed, it is necessary to again examine the channel before the work can be accepted, to detect the presence of any rock which is liable to be thrown in from the cribs, or the coffer-dams themselves, as they are dredged up. A very small portion of rock thus thrown in would render the channel dangerous. Were the bottom through which we cut of sand or mud, these extreme precautions would not be necessary.

I called your attention some time ago to the electro-magnetic and self-recording sounding machine, invented in this office by Lieut. E. F. Hoffman. I was so well assured of its ultimate success, and great economy as compared with the other methods of sounding, as well as its greater accuracy, that I recommended its use, and received your permission to construct one. The machine is now nearly ready, and will be used in making the examinations this season.

After the channels through Moline, Duck Creek, Campbell's, and Sycamore Chains are excavated completely, the improvement will be felt and appreciated. It is expected that this will be done the coming season, leaving a few small patches only that will make the channels inconvenient.

It is to be hoped that the next appropriations by Congress will enable the work of fully completing the above-mentioned channels to be done, and enable us to make the proposed cuts at Smith's, St. Louis, and Lower Chains, and to remove the patches off Winnebago Island and Crab Island.

I have not submitted any estimate with this report, as I submitted one to you a short time ago.

I am, general, very respectfully, your obedient servant,

CHARLES J. ALLEN,
Captain of Engineers and Brevet Major.

Brevet Major General J. H. WILSON,
United States Army, Keokuk, Iowa.

Official copy:

J. E. GRIFFITH,
Second Lieutenant, Corps of Engineers.

F.—*Abstract of contracts entered into during the fiscal year ending June* 30, 1869, *for the improvement of the Rock Island Rapids of the Mississippi River.*

No.	Date.	Names and residence of contractors.	Names and residence of bondsmen.	For what purpose.	Amount.
1	June 29, 1869.	Chas. G. Case, Fulton, N. Y. Frederick D. Van Wagenen, Fulton, N. Y.	Sands N. Kenyon, Fulton, N. Y. Thomas M. Chesebro, Fulton, N. Y.	The improvement of Campbell's Chain, &c.	$135,000

I certify that the foregoing abstract is correct.

J. H. WILSON,
Lieutenant Colonel and Bvt. Maj. General U. S. A.

U. S. ENGINEER'S OFFICE,
Keokuk, Iowa, June 30, 1869.

OFFICE OF THE UNITED STATES ENGINEERS,
Keokuk, Iowa, June 15, 1869.

GENERAL: I have the honor herewith to report the results of the investigations of the party sent out by you, under my charge, during the fall of 1868, for the examination of sites for locks and dams on the Illinois River below La Salle. Monthly reports of the field operations being already in your hands, I shall confine myself in this report to a statement of the general results obtained. Former surveys had already demonstrated that the Lower Illinois River would not furnish any sites perfectly adapted to the location of a lock and dam, and it had been understood that the selection of a site would have to be merely a choice among the least objectionable ones. It was known that it would have been in vain to look for a rock foundation in this river; that the wide bottoms on either side abounded with lakes and sloughs, communicating frequently with the main water-course, and inviting the latter to escape laterally if prevented by any obstacle from proceeding directly; and that in most places the soil of the banks, being very light and porous, and allowing the water to filter through it to considerable distances, was quite unfavorable to the security of any permanent structure at the shore of the river.

The unreliability of the river bed is a defect which cannot be wholly remedied, although care has been taken to select sites least objectionable in this respect. The outlets of lakes and sloughs, wherever they should be found to allow the water to escape laterally, must be filled up, which fortunately can be done without difficulty, and at little expense. The porous character of the soil of the river banks is a more serious impediment. The extent to which filtering is going on at frequent intervals along the entire course of the river can best be observed during the driest season of the year, when for several feet above the water of the river the ground, whether sand, gravel, or clay, is saturated with water, innumerable diminutive springs issuing all along from the banks, every one of which is filtered from lakes in some instances more than a mile off. In fact the whole ground in such places is permeated by water, and instances will be shown in the detailed reports where impassable swamps, when prevented from issuing into the river by impermeable strips of soil, are higher by several feet than the dry ground separating them from the river.

In selecting sites for the location of locks and dams particular attention was paid to the following points:

1. Avoiding a straight channel above, so as to keep the lock out of danger of drift wood and ice, sharp bends were likewise rejected, for the reason that the concave side would necessarily be subjected to abrasion of the shore, endangering the anchorage of the dam.

2. For this reason every abrasion, however slight, on either bank, was carefully noted, and only such points chosen as presented a gradual and easy slope on both sides. The chainmen were instructed to note every abrasion in the chain-books, and they were also noted down in the field-books for topography.

3. Ice-marks on trees were likewise entered into chain-books and in the topographical notes. Although usually far above the comb of the dam and the coping of the lock, they yet indicate the places were dangers from ice are most to be apprehended.

4. The minimum height of bank on either side was fixed at ten feet above low water—more than that is rarely to be obtained.

5. Although care was taken to avoid places above the lower outlets of lakes or sloughs, it was yet found impossible to keep entirely free from this objectionable feature. The only remedy for this, as above stated,

is the thorough stopping up of all outlets from the river into the lake at high water above the dam.

6. The character of the river-bed was carefully noted at every sounding; but definite information on this point can only be obtained by more detailed operations than either time or means allowed on this expedition.

Before entering on separate descriptions of the several sites examined, it will be necessary to report on the modus operandi by which the results embodied in them were obtained.

SURVEYS.

At every locality both shores were surveyed by theodolite and chain, connected at each extremity, and when desirable at intermediate stations by triangulation. Each day's work was tested in the evening, and the platted results show but insignificant discrepancies due to slight inaccuracies in chaining through heavy underbrush, &c. It is unnecessary to go into any further description of this part of the work. It had been the intention to run cross-sections from bluff to bluff at each of the sites selected at right angles to the course of the river. This, in most instances, was found to be impracticable, the swamps and lakes from heavy rains before and during the progress of the survey proving impassable, except at certain points, which it took a good deal of trouble to discover. Cross-sections were, however, made at every location sufficient to show the character of the valley, in connection with the lines of level. The results are embodied in the maps herewith submitted, seven in number, showing the topography of the site, cross-section of the valley, and profiles of the river at the point selected, together with such other information as was thought to be useful or interesting.

SNAGGINGS.

The comparatively high stage of the river, and the considerable fluctuations in the stages at the several localities examined, were quite unfavorable to the determination of discharge. According to instructions the velocities were observed by means of mid-depth floats, constructed as follows:

A one-inch pine board, eight inches square, supporting a small flag, served as guide for observation, and as support for the float. A one-quarter-inch rope, divided into feet by pieces of tape, was attached to this by four strings, at a distance of one foot from the surface of the guide-board, and at the average mid-depth of the stream to an oblong box, open at both ends, and made of inch pine two feet long, and ten inches square, loaded with scrap-iron and stone to the capacity of the guide-board. The float could thus be regulated to any depth without loss of time.

The fluctuations in the stages of water at the several localities were as follows, the figures indicating the height above low-water of 1867:

At Willow Island, 1.3 foot; velocity, 0.40 foot; 0.44 foot per second.

Copperas Creek, 1.7 foot; velocity, 0.87 foot; 0.99 foot; 1.09 foot per second.

Spring Lake, 1.5 foot; velocity, 0.53 foot; 0.60 foot; 0.42 foot per second.

Frederick, 1.3 foot; velocity, 0.80 foot; 0.83 foot; 0.77 foot per second.

Lagrange, 4.3 feet; velocity, 1.70 foot; 1.70 foot per second.

Naples, 3.9 feet; velocity, 1.53 foot; 1.90 foot; 1.85 foot; 1.65 foot; 1.80 foot per second.

Bedford, 4.0 feet; velocity, 1.58 foot; 1.27 foot; 1.30 foot per second.

The velocities here given represent mid-depth velocities on the subdivisions of the cross-section, counting from the left to the right shore.

The following table shows the actual discharges at the time of observation, together with the stage of water above low-water of 1867:

Locality.	Discharge.	Stage of water.
	Cubic feet.	*Feet.*
Willow Island	2,788	1.3
Copperas Creek	2,509	1.7
Spring Lake	2,527	1.5
Frederick	2,590	1.3
Lagrange	9,746	4.3
Naples	10,366	3.9
Bedford	9,134	4.0

Reducing the areas of cross-sections to low-water, but retaining the mid-depth velocities obtained, the resulting discharges are so much in excess of those obtained at corresponding localities during low water of 1867 as to render such procedure altogether valueless. This proves that mid-depth velocities are materially affected by comparatively insignificant changes in the stage of water. I must here state, also, that in shallow streams, like the Illinois, the effect of wind upon mid-depth floats is very considerably greater than it was found to be on the Lower Mississippi, as stated in the "Report upon the Physics and Hydraulics of the Mississippi River." Direct observations have shown that on the Illinois River every breeze affected the floats materially, both in direction and velocity. All observations made during a perceptible breeze were consequently rejected, and advantage was taken of every moment of perfect calm. The soundings were made on the plan adopted by the hydrographic party of 1867, the sounder lining himself by two flags set up on shore in the direction required.

Profiles of the soundings made, with the necessary reference lines of high and low water will be found on the maps accompanying this report.

BORINGS.

The borings at the several sites examined were necessarily of limited extent. As far as they went they merely proved what had been surmised before, that within twenty-four feet at least from the bed of the river no firm foundation can be found; and it is safe to predict that no better result will be obtained by boring to more than to twice that depth. The boring apparatus was made to order by a blacksmith in Keokuk, and will be best explained by the sketch in original manuscript.

The borer proper was made of one-inch square iron, forged at the foot into the shape shown in the sketch, and ten feet long.

Two more lengths of the same one-inch iron rod, each ten feet long, were made to join the borer by a connection as shown in the figure, bulging slightly beyond the thickness of the rod, so as to allow an iron jacket to be driven firmly over the joint by a few taps with a hammer. Two iron sockets to receive wooden levers were movably attached to the rods by a jacket and screw. To a depth of twenty-four feet this apparatus was found to work well, at an average rate of about five feet per hour, worked by two men.

Willow Island site.—The site selected for this dam is about midway between the foot of Willow Island and the town of Henry, a short distance below the mouth of Senachewine Lake. The width of the river

here is six hundred and sixty feet; the left bank where the lock should be located, thirteen feet above low-water, but the ground is rapidly sloping towards the interior to five and a half feet. The wet marsh midway between the left shore and the bluff is more than three feet higher than the dry ground intervening between it and the river. The right shore presents a gradual slope of compact gravel back one hundred feet to the foot of the gravel terrace, which extends from the lower outlet of Senachewine Lake to Henry, fifty-five to fifty-nine feet above low water. This terrace is composed of clay and gravel in about equal proportions, with some larger boulders near the base.

The dam for part of the way would be in a depth of fourteen feet at low water, with a gravel bottom for about half its length, and mud the other half.

The location of a lock and dam at the foot of Willow Island, as at first projected, is open to several grave objections. The channel above this place, on either side of the island, is perfectly straight, affording no protection from anything that may come down the river. The right bank is too low to meet the views expressed above, being but seven feet above low water. The outlet of Senachewine Lake is but a short distance below this site, and its connections with the river above are numerous, although only occurring at high water.

A more desirable site than this would have been at the foot of Henry Bar, a short distance above the town of Henry, and below the mouth of Sandy Creek. The river here is narrow, about six hundred and fifty feet wide, with a depth of five feet, gravelly slope, and gravel terrace on the right bank, and a clay slope ten feet high on the left. For a dam location it would probably be superior to the one selected, with the additonal advantage of submerging Henry Bar; but for a lock site the latter presents far greater advantages. I have not found a place near Henry on either shore, where a lock would not be exposed to the full sweep of the current. A sketch of this vicinity, taken from the maps furnished by the hydrographic party of the survey of 1867, will be found among the other maps of the Willow Island site on sheet No. 1.

Copperas Creek site.—The site chosen for the Copperas Creek lock and dam is at station N, (see sheet No. 2,) the lock to be located on the west shore. Both banks here are firm, gradually sloping, and about ten feet above low water. The west shore is free from danger of ice. The principal objection to this site is the shallowness of the water, 3.4 feet being the greatest depth at low water, but this may be balanced by the unusually firm character of the river-bed, which is, with the exception of a short distance from the west shore, composed of gravel all the way to the opposite shore, mixed with some shells and sand. Another objection, which is, however, common in a greater or less degree to all sites that can be chosen anywhere on the river, is the presence of a very large lake (Spring Lake) along the eastern border, with a main outlet below the site, and several smaller ones above it. Another site was therefore examined below the main outlet of Spring Lake. The borings made in the river-bed near the western shore reveal nothing but a bed of blue plastic clay, apparently quite free from sand, and very tenacious; twenty-four feet were bored through without any change. A specimen was preserved from a depth of twenty-four feet below the bottom. The dam would be six hundred and eighty feet long, timber for which can be obtained in abundance on either shore. Rock for filling will have to be floated down from above.

The bluff on the west side is mainly composed of drift, (loam, sand, and some slight indications of gravel,) and is on an average one hundred

and thirty feet high above water. At the foot of the bluff, in the bed of Copperas Creek, some twenty feet of coal shale were found, containing a thin bed of impure coal and bituminous slate. The lower portion of the shale is seamed with nodules of clay-ironstone, resembling very much those found on Macon Creek, near Morris, renowned for the paleontological treasures they contain, but no fossils were found at this locality, except some indistinct flattened shells in the shales, among which a *Chonetes mesoloba*. Large blocks of drift conglomerate, quite hard and compact, were found overlying these coal-measure beds, very similar to those of Hennepin and Peoria. A section of this locality will be found on sheet No. 2.

Spring Lake.—As an alternate for the Copperas Creek site, another location, below the mouth of Spring Lake, was examined. The only safe site was found at the Liverpool Ferry Landing, where the river is contracted to a width of four hundred and eighty feet. The left bank here is thirteen feet high, sloping towards the interior to an average level of seven and one-half feet above low water, a rather desolate region, with plenty of marsh, and an almost impenetrable jungle of cockle-burs.

The bottom is bounded by a sand ridge or terrace sixty-two feet above low water, and covered with small black-jack, distant from the river one and quarter mile. The right bank at Liverpool slopes gradually to twenty feet above low water, while the marsh in the interior is but six feet above low water. The bluff, two and a quarter miles back from the river, is one hundred and forty-four feet high; its base consists of coal-measure shales, thirty feet or more in thickness. No other rock observed.

The objection raised against the Copperas Creek site, on account of the shallowness of water, certainly does not apply here, with a depth of eighteen and a half feet above low water. There are lakes and marshes on both sides of the river; the bed of the river consists of soft mud on the eastern half, and gravel and mud on the western.

No borings were made, as the boring apparatus would only reach twenty-five feet, twenty of which would have been occupied by water.

Frederick.—At Frederick the west bank, about one hundred feet from the edge of the water, is twelve feet above low water, rising to thirty feet at the town of Frederick. The bluff is distant from the river one-half mile and two hundred and thirty feet high. The top of the mound at its summit is two hundred and thirty-eight feet high. The base of the bluff is formed of four feet of bluff and blue limestone, containing some large *conularia* overlaid by blue sandy shale of the coal measures. For fifteen feet above this the drift loam is stratified with horizontal seams of pebbles and small boulders; the rest of the bluff consists of unstratified loam, sandy towards the top.

The east bank, opposite Frederick, is low, strongly abraded, and the exposed trees show heavy ice-marks. The site selected for a lock and dam is at station H, (see sheet No. 4,) where the river is six hundred and sixty feet wide, its greatest depth at low water six feet, with sandy bottom throughout.

The borings in the river-bed reveal the usual mixture of a great deal of sand with some little black mud. The west bank is fourteen and a half feet high, with a gradual slope, and quite firm. The prairie, six hundred feet back of the river, is eleven feet above low water, and extends to the bluff some two miles distant. The east bank is twelve feet above low water; but the distance between the river and Beardstown Bay, fourteen hundred feet, is traversed by smaller sloughs parallel to the river, and only four or five feet above low water.

The town of Beardstown is from twenty-two to twenty-six feet above low water; the soil is very sandy. The river bottom here is five and a half miles wide, almost all of it above high water, and intersected by numerous sand ridges. The bluff is two hundred and thirty-three feet high, the mound on its summit two hundred and forty-two feet. At an elevation of one hundred and thirty-four feet, there is an outcrop of fine-grained buff sandstone with some shales. The sandstone is similar in character to that at Lagrange, overlying the limestone and coal. No survey was made above Frederick to Sugar Creek, because reconnaissance had shown the left bank for all that distance to be too strongly and abruptly abraded.

Abundance of rock for filling cribs can be obtained from Sugar Creek, which during high water is navigable for medium-sized flats up to the limestone quarries. The rock is not fit for heavy masonry.

Lagrange.—The best site for a lock and dam in this vicinity is found directly in front of Lagrange, at Station 5, (see sheet No. 5.) The river here is six hundred and sixty feet wide at low water, eight hundred and sixty-five between banks. The greatest depth is found close to the east shore, where the lock should be located, 7.3 feet at low water; but the river is quite shallow for four-fifths the distance across.

The west bank is twelve feet above low water at sixty feet from the water's edge, rising to forty feet at the foot of the bluff, eleven hundred and fifty feet from shore. The bluff, containing coal at an elevation of ninety-six feet, is two hundred and seventy-eight feet high. The coal has been worked in numerous pits, but does not appear to be of very good quality.

The east bank is eleven feet above low water, with a gradual and easy slope, and firm soil, but immediately descends to a slough, seven feet above low water, and at a distance of eight hundred feet to a lake, the water of which is at nearly the same elevation with that of the river. The outlet of this lake is but a short distance below the proposed location.

Naples.—The only acceptable location for a lock and dam in this neighborhood was found at Station 6, (see sheet No. 6,) a short distance below the wharf at Naples. The river here is eight hundred and ninety-three feet wide; at low water, its greatest depth, 6.6 feet; and the bottom consists mostly of sand and hard material, gravel and shells, with some mud. The west bank is firm and gradually sloping, 12.2 feet above low water. The lake, one-fourth of a mile back from the river, is nine feet above low water; the general level of the prairie extending to the bluff is eleven feet, rising to eighteen feet nearer to the foot of the bluff where the land is cultivated.

The elevation of the foot of the bluff, two and one-fourth mile distant from the river, is twenty-one feet; that of its summit, two hundred and three feet. At an elevation of sixty feet an outcrop of thin-bedded limestone was observed; no other rock visible.

The east bank is sandy, and slopes gradually, for a distance of sixty-eight feet, to an elevation of fifteen feet, then rises, almost perpendicularly, four feet. The abrasion here is very strong, but can only be caused by high water. Thence the land is apparently a dead level at an elevation of nineteen feet, for a distance of about two thousand feet; in fact, with the exception of a slight depression or slough immediately back of the town, virtually a level back to the foot of the bluff, a distance of about four miles.

The bluff directly above Naples is composed of sand throughout, regularly stratified in its steep escarpments. For about one hundred feet

from the edge of the water it slopes gradually to an elevation of fifteen feet, thence very abruptly, and in some places nearly perpendicularly, to thirty-five feet. The average height is forty-six feet; the highest point, fifty-four feet. To the landward it slopes gradually to the general level of the bottom lands. The elevation of this ancient sand-bar furnishes us with the approximate height of the Illinois River at the time when it filled its wide valley.

Bedford.—Considerable difficulty was experienced to find a site near Bedford that would at all answer even the modest requirements proposed. A site was at length determined on at Station 10, (see sheet No. 7,) as presenting the least objections.

The river here is, at low water, nine hundred and eighty-six feet wide; its greatest depth, seven and one-half feet; the bottom, about one-half mud and one-half gravel and shells.

The west bank is firm, gradually sloping and about thirteen feet above low water, gradually rising to the foot of the bluff, one-fourth mile distant. The bottom is well timbered and dry. The bluff here is formed of massive beds of light-colored, semi-crystalline limestone, at least seventy feet in thickness, presenting high perpendicular escarpments, and altogether the most picturesque views to be found anywhere on the lower Illinois. Pilot peak is the most remarkable of these. The summits are dotted with mounds, some of them of considerable dimensions, and it cannot be denied that whatever races built these, the only remaining traces of their existence, they must have had an eye to natural beauty, as the mounds are invariably found wherever the prospect is fine and extensive.

The east bank, at the site selected, is less favorable than the western, being about ten feet above low water, and a deep though dry slough running parallel with the shore, within two hundred and fifty feet, frequently communicating with the river by shallow outlets. The timber is heavy, with a dense undergrowth, and impenetrable, except at the driest season, and then only at an expense of time which we could not afford.

In order to obtain a fair idea of the river bottom, a cross-section was made a short distance above Bedford. On the west bank the ground rises rapidly to the foot of the bluff, which is here close to the river, and rises to a height of two hundred and eighty feet. On the east side the bank is fifteen feet above low water, and after crossing a marshy run, emptying into the river at the head of Shin Island, a wide prairie is reached, elevated thirteen and a half feet above low water, and intersected by narrow marshes, which unite a short distance below into a very extensive marsh or lake. The bluff on this side, two and a half miles from the river, is one hundred and ninety feet high, (the mound on its summit two hundred feet,) and is composed altogether of loam, very precipitous, and cut up by deep ravines, perfectly bare of timber, except on the summit.

The width of the valley between the tops of the bluffs is 3.2 miles. The unusual severity with which the winter set in after the completion of the Bedford survey rendered it impossible to undertake the examination of the only remaining site, that near Six-mile Island.

A more extended time and a more favorable season might probably have enabled us to find some more favorable locations for the construction of locks and dams than those herein reported on. But from a rather familiar acquaintance with the Illinois River, I can say without hesitation that I do not consider that river at all adapted to slack-water navigation. This mode of improvement should only be resorted to where all other

means are clearly impracticable, and where the only alternative is that or no navigation at all. I do not pretend to say that dredging alone would bring the Illinois to that condition which it is entitled to, nor that an attempt should be made to perfect its navigation to the proposed standard in a few years time, but after another two months' walk afoot along its banks, I am more than ever convinced that, dredging, with its indispensable accessories—catch basins for the sediment—bearing tributaries and longitudinal dikes, where ever found advisable, would gradually, as the requirements of commerce advance, deepen and regulate its channel to the full satisfaction of all demands that ever will be made upon it.

Respectfully submitted.

H. A. ULFFERS,
Civil Engineer, Assistant.

Brevet Major General J. H. WILSON,
Lieutenant Colonel U. S. A., Keokuk, Iowa.

APPENDIX J.

UNITED STATES ENGINEER OFFICE,
No. 23 *Rampart Street, New Orleans, July* 7, 1869.

GENERAL: In compliance with the requirements of circular, dated Headquarters Corps of Engineers, June 10, 1868, I have the honor to submit the following annual report of progress made in all works of river and harbor improvements and surveys under my charge, for the fiscal year ending June 30, 1869:

1. Survey of Galveston Harbor, Texas, with a view to forming plans for its improvement and preservation.

This work was completed and full report made by Brevet Brigadier General M. D. McAlester, on the 9th of June, 1868. There is yet remaining of the appropriation made for carrying on the survey the sum of $25 92, now in my hands, which amount is no longer needed on this work, and may be returned to the general appropriation from which it was taken.

2. Improvement of the mouth of the Mississippi River.

The last annual report rendered by Brevet Brigadier General M. D. McAlester, major of engineers, in charge of the work, gave a detailed account of the construction and working to the date of July 1, 1868, of the steam dredge-boat Essayons, especially designed by General McAlester, and built under his direction for this work.

The Essayons was at that date just out of Hampton Roads, bound for this port, and yet in the hands of her contractors. She arrived at New Orleans July 16, and was immediately placed in dock to repair damage sustained during her voyage, and to make such alterations of her machinery as the experience gained by her trip suggested.

The voyage from Boston to New Orleans disclosed several minor defects in the construction of her machinery, but proved her to be, with the latter in good working order, a reliable, seaworthy vessel.

All such repairs and alterations deemed advisable, as by the terms of their contract devolved on them, were made by her contractors, in whose hands she remained until the 6th of August, at which date she was formally turned over to the United States.

The time intervening between the 6th of August and the 3d of

September was consumed in making such further alterations from the original plan as did not properly devolve on the contractors.

On the 3d of September, the vessel sailed for Pass à Loutre, (previously selected for improvement,) but, owing to a series of accidents, (mainly due to the inexperience of the assistant steam engineers, who were not well acquainted with the working of the peculiar machinery of the vessel,) only one and one-half hour's work on the bar was done during the month, the remainder of the time being spent in making repairs.

Lieutenant D. W. Payne, Corps of Engineers, United States Army, during this time was in active superintendence of the work, under the orders of General McAlester. I extract from his report to me, dated July 2, 1869, to show the progress made in October and November, 1868:

"In October, the depth of water in the channel was increased from twelve feet six inches to fourteen feet. The vessel worked nine days and seven hours during the month. She was prevented from working the remainder of the time by bad weather and by accidents to her machinery. Two blades of the forward screws were broken off on the 1st, by striking a log while running down the river. On the 14th, the two remaining blades were broken off by striking something hard in the channel. From the 14th to the 30th, work was continued with the after scraper. On the 30th, the vessel was taken to New Orleans to repair the forward screw, and did not return to Pass à Loutre until the 19th of November, by which time the channel had filled so as to give only eleven feet six inches of water on the bar."

During November, only one and one-half day's work was performed. The depth of water on the crest of the bar was increased to thirteen feet.

On the 25th of November, the Essayons was ordered to New Orleans, preparatory to a transfer from General McAlester to Colonel F. E. Prime, and was detained until the 8th of December.

Only one day's work was done at the mouth of the river in December, and that resulted in breaking two blades of the forward screw, after which the vessel was again brought to New Orleans for repairs. These repairs, owing to delay in receiving the new blades required, detained the vessel in New Orleans until the 3d of February, 1869. During this long detention the reversing gear of the engine, which had given much trouble, was put in good working order.

The Essayons returned to Pass à Loutre on the 3d of February, 1869. Lieutenant Payne reports for the remainder of the fiscal year as follows:

"On the 4th of February, but eleven feet six inches of water was formed on the crest of the bar at Pass à Loutre. Eleven and one-fifth days' work were done by the Essayons during February. She was prevented from working during the remainder of the month by thick fogs, taking in coal, and making repairs. Two blades of the forward screw were broken off on the 9th. The depth of water over the bar was increased from eleven feet six inches to fourteen feet.

"In March, six and one-half days' work were performed, and by it the depth of channel increased to fifteen feet. Operations were very much hindered by fogs. On the 29th, another blade of the forward screw was broken, leaving but one for service, and in consequence the vessel was again taken to New Orleans for repair of screw, and did not return to Pass à Loutre until the 20th of April. During her absence, the channel filled to fourteen feet six inches.

"During April, after her return to Pass à Loutre, the Essayons was

prevented by thick and continuous fogs from working but one and one-half days. On the 28th, one blade was broken off the forward screw.

"In May, the depth of water was increased to seventeen feet four inches by fifteen and one-half days' work; the remainder of the month was taken up in coaling and repairing scraper tackle.

"In June, thirteen days' work increased the depth of water throughout the channel formed by the Essayons to seventeen feet eight inches, as shown by survey made on the 18th, at which date work was virtually suspended."

On the 28th, while helping a very heavy vessel over the bar, another blade of the forward screw was broken, and, on inspection, the vessel was found unfit for further work until thoroughly overhauled and repaired.

I sum up the time actually employed in work on the bar at Pass à Loutre and the results as follows:

From the 3d of September, 1868, to the 3d of February, 1869, out of 153 days, only 11¾ days' work with the dredging screw, and 16 days' additional with the rake. The condition of the bar not improved.

From the 3d of February to the 18th of June, 1869, 135 days, with 57¾ days' work on the bar, resulting in a clear, direct channel across the bar 175 feet wide at its narrowest part, and giving seventeen feet eight inches as least depth of water. The increase in depth at the crest of the bar was six feet two inches.

From this showing it may be fairly inferred that continuous work would have cleared a channel giving twenty feet, (the full depth to which the Essayons can work.)

During the first half of the fiscal year, the steam machinery of the Essayons gave great trouble, but after the 1st of January, 1869, worked in the most satisfactory manner, leaving but few alterations to desire.

The greatest difficulty and delay arose from the frequent and unavoidable breaking of the blades in the dredging screw.

These blades being made of cast iron, having a lever arm of six feet, revolving, when at work, with a circumference velocity of twenty feet per second, and being subject to frequent severe shocks from striking mud lumps, timber imbedded in the sand, and ballast deposited on the bar by vessels lightening over, were necessarily the most liable to accidents of any portion of the vessel, and, at the same time, the most troublesome to replace.

During the year ten of these blades were broken, as above indicated, and during nearly the whole of the working time reported, but two blades in the dredging screw were serviceable.

The substitution of the new blades for those broken several times necessitated docking the vessel, at an average expense of $700 per blade, not including cost of new blade.

To avoid, if possible, future expense and delay in the work, (which cannot be avoided with the screw as at present constructed,) it is recommended to substitute for the screw now in use one of greater strength, the additional strength to be gained by casting the blades of Bessemer steel, and by modifying the form of the blades and hull so as to give a greater cross-section to the pintle of the blade at the point subject to the greatest strain.

The shaft boxes, through the dead wood, are arranged to admit water from the outside for the purpose of cooling the shaft. This water, while the vessel is working, is full of mud and sand stirred up from the bottom of the river by the screw, and causes the rapid wear of both shaft and packing. So great has been the damage from this cause that I do not

consider it safe to work the forward screw, until the packing (and it is presumed the brass bearings of the shaft) are renewed. I propose, as a remedy for this defect, to close the end of the shaft box and carry surface water through iron pipes from amidships, to give the necessary supply; the water after use to be discharged inside the vessel and pumped out with the bilge-water.

The rake designed to aid the screw in stirring up the material of the bar is not of sufficient weight or length to be most effective, and should be so constructed as to scrape or carry as well as loosen. The vessel has a surplus of power that can be used to advantage in this manner.

As now arranged, the rake engine and the pumps are worked direct from the main boilers and to a disadvantage, owing to the low pressure under which the latter are run; not only one half the power of the rake engine can be developed with low pressure feed, and in consequence the handling of the rake has not been as rapid as could be desired. It is often necessary to run the pumps after working hours, and to keep up steam in one of the boilers to do so, at considerable expense for fuel, and with additional wear of boilers, which is an item of importance in view of the great cost and short lives of marine boilers in Mississippi River water. The useful effect of one boiler is taken from the main engines during the whole time of work. From consideration of the above, I would recommend a high pressure donkey boiler, placed in one of the after coal bunkers, and drawing through the main chimney, for the use of the pumps and rake engine.

I would also recommend, should the rake engine now in use not give sufficient power with high pressure feed, the substitution for it of an engine of fifteen horse-power.

The present cabin is not large enough for the proper accommodation of the officers of the vessel. I propose three additional state-rooms to be built over those now in use, and in extension of the two pilot-houses.

The foregoing are the only important modifications and additions I have to recommend at present; others will no doubt be suggested when the vessel is thoroughly overhauled, as is proposed to be done this summer. General repairs to hull and machinery are necessary, and have been specified in previous report.

The distance of Pass à Loutre from a coal market, together with the difficulty and expense which would attend the construction of a coal depot within a desirable distance of the work to be done by the Essayons, led to the purchase by General McAlister, in April, 1868, of the two-masted barge Cavallo, measuring 212.54 tons, as a tender. This barge has, since her purchase, been constantly employed in supplying the Essayons with coal from New Orleans, and for the storage of supplies of all kinds required on the work at Pass à Loutre. Her services have been of great value, both on the score of economy in the items of transportation and storage, and in the facilities she has afforded for carrying on the work regularly. She was purchased for $5,000.

I would recommend that as soon as it can be done without extra expense she be hauled up on the ways and her bottom examined and repaired. It will probably be necessary to sheathe her either with wood or zinc, as she has not been out of the water for nearly a year and must be worm eaten; how badly cannot be determined until she is taken out.

The frequent accidents to the dredging screw of the Essayons, which necessitated entering a dry dock for repairs several times during the fiscal year, were taken advantage of by the Dry-dock Association of New Orleans to extort an exorbitant rate for dockage from the government.

The Essayons was classed as an extraordinary vessel, and charged double rates, or $812 for entrance, instead of being taken at regular rates and charged for tonnage over her measurements, as is the custom when merchant vessels loaded are taken up.

To protect the government from this imposition, Brevet Colonel F. E. Prime (then in charge of this work) contracted for an end dock, which was built at an expense of $2,000, and was ready for use April 9, 1869, since which date her services have nearly repaid her cost. It will be necessary to partially recaulk her above the water-line, at slight expense. She is now in good condition with but a few seams open.

I cannot too earnestly recommend the completion of Gen. McAlester's plans for this work, by the early construction of a vessel similar to the Essayons, but of deeper draught, to take the place of the latter when disabled, and make the work continuous.

This recommendation of General McAlester has gained weight from the experience of the past year, and there can now be no doubt of the successful opening of the Mississippi River to vessels drawing twenty-four feet, if his plans are fully carried out.

Another rcommendation made by General McAlester I would again call to your attention as of the first importance, having in view the proper preservation of the channel after it is formed. I refer to the appointment of some person officially charged with regulating the time, order, and manner in which vessels shall make use of the channel across the bar, and with lighting the buoys at night.

I would suggest as important regulations that "but one vessel at a time be permitted over the bar," and that sailing vessels be required to take a tow both in and out. The object in view is the preservation of grounding on the sides of the channel, and either blockading or shifting it from its present direct course.

I may here explain, in further support of the recommendation, that certain unscrupulous parties interested in maintaining the intricate and difficult entrance via South West Pass, without the check proposed, will at any time have it in their power to temporarily blockade Pass à Loutre, to the great inconvenience of commerce and hindrance of the work.

The commerce of New Orleans has been for so long a time dependent on the navigation of South West Pass, and on the pilots and tow-boat association controlling it, that ship-owners and shipping agents are slow to grasp the advantages offered by the work at Pass à Loutre.

On taking charge of this work in June, 1869, I found that not one vessel of considerable draught had essayed the channel formed by the Essayons, although during the entire month of May seventeen feet clear, and a direct channel 175 feet wide, had been publicly reported by the officer in charge as available at Pass à Loutre.

The actions of owners and agents was accounted for in two ways:

1. The tow-boat association, if they could avoid it, would not send their boats or tows via Pass à Loutre, and masters would not return through that pass without having assistance at hand, for fear of grounding.

2. The South West Pass pilots and tow-boat association persistently misrepresented the condition of Pass à Loutre, and their reports gained credence with many, in preference to the reports of the officer in charge of this work.

For the purpose of refuting in an unanswerable manner these false reports, and showing the value and amount of work done by the Essayons, her master (Captain Putnam) received orders to tow out or in all

vessels that might present themselves at Pass à Loutre. At the same time arrangements were privately made for sending a few such out. As the result I have to report as follows:

On the 17th of June the steamship Concordia, drawing 17 feet 8 inches, passed out without assistance and without detention.

On the 18th the bark Britannia sailed in, drawing 17 feet.

Other vessels followed as indicated below, viz:

June 20.—Steamship United States, in, drawing 16 feet.
June 23.—Ship Wm. Woodbury, out, drawing 17 feet 10 inches.
June 24.—Ship Polar Star, out, drawing 17 feet.
June 25.—Ship Lizzie Moses, out, drawing 18 feet 3 inches.
June 26.—Ship Perseverence, out, drawing 17 feet 10 inches.
June 26.—Steamship Cromwell, out, drawing 16 feet 6 inches.
June 27.—Steamship Geo. Washington, in, drawing 16 feet 10 inches
June 30.—Steamship Kensington, in, drawing 15 feet 6 inches.
June 26.—Steamship Tranquebar, out, drawing 18 feet 9 inches.

This latter vessel grounded in mid-channel, and remained nine days, within a few feet of deep water; during that time a good but narrow channel, seventeen feet deep, was available on each side of her. Her grounding is directly traceable to the carelessness or intention of the pilot aboard, who tried to carry her through at low tide, instead of waiting for the flood, when she could have gone over without trouble. An authorized government officer on hand, to have directed her crossing, would have prevented detention of the ship and damage to the channel.

By the practical demonstration reported above, the work at Pass à Loutre was placed before the public in its true light, and the object in making it gained.

I submit the following information relating to paragraphs II and III, circular of June 10, 1868.

II. (3.) The following amount can be profitably expended on the work during the present fiscal year:

For providing the second of the two dredge-boats authorized by the joint resolution of Congress, approved March 29, 1867	$275,000 00
For working expenses, repairs, and alterations of Essayons	70,000 00
For working expenses and repairs of dredge-boat No. 2, from 1st of April, 1870, to June 30, 1870, (3 months)	20,000 00
Total	365,000 00

For the year ending June 30, 1871, will probably be required for working expenses and repairs of two dredge-boats the sum of	$125,000 00

II. (4 and 5.) The work is located in the collection district of New Orleans, Louisiana, and near the light-house of Pass à Loutre, mouth of the Mississippi River.

(6 and 7.) See statement appended marked A.

(11.) *Statement of cash.*

Amount available from fiscal year ending June 30, 1868..	$36,000 00
Additional allotment for 1868 and 1869..................	50,000 00
Available for year ending June 30, 1869..................	86,000 00
Withheld for payment of internal revenue................	450 00
	85,550 00
Total drawn during fiscal year..........................	69,500 00
Amount available June 30, 1869..........................	16,050 00
Deduct outstanding indebtedness.........................	3,162 49
Available for year ending June 30, 1870..................	12,887 51
Additional allotment for 1869 and 1870..................	45,000 00
Amount available for 1869 and 1870.....................	57,887 51
Amount required for the year ending June 30, 1870......	$365,000 00
Amount estimated for the year ending June 30, 1871.....	125,000 00

III. This does not admit of permanent completion.

In order to maintain, at all seasons of the year, a channel depth of twenty feet across the bar at Pass à Loutre, an annual expenditure of $125,000 will be required; of which amount, $100,000 is estimated for the working expenses of two dredge-boats, and $25,000 for necessary repairs, buoys, and contingencies.

All of which is very respectfully submitted.

C. W. HOWELL,
Captain of Engineers and Brevet Major U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers U. S. A., Washington, D. C.

Statement of commerce, to the benefit of which the work for the improvement of the mouth of the Mississippi River contributed, during the fiscal year ending June 30, 1869.

New Orleans, Louisiana, is the collection district in which the work is located. The work is situated near light-house at Pass à Loutre.

Number of entrances of sail and steam vessels.......	1,667
Number of clearances of sail and steam vessels......	1,968
Total number of entrances and clearances.....	3,635
Total tonnage of vessels entering and clearing........	2,582,764 49
Total value of imports, specie free and dutiable......	$11,775,553 00
Total value of exports of domestic commodities to foreign countries..................................	$75,128,932 00
Total value of exports of foreign merchandise to foreign countries..................................	754,858 00
Grand total value of exports..................	75,883,790 00

Amount of revenue collected as duties on imports during the fiscal year	$4,263,385 14

I certify this to be a correct statement, and from the best information I have been able to obtain.

C. W. HOWELL,
Captain of Engineers and Brevet Major U. S. A.

APPENDIX K.

UNITED STATES ENGINEER OFFICE,
Corner Houston and Greene Streets, N. Y., January 29, 1869.

GENERAL: I have the honor to report the completion of the survey and examination of the mouth of St. John's River, executed in compliance with instructions from Headquarters Corps of Engineers, dated July 27, 1868, with a view to meet a request made by the United States Senate Committee on Commerce, for "estimates of the expense of deepening the channel at the mouth of St. John's River, Florida, so that it will answer the demands of commerce."

A chart of that portion of the river and shore lines embraced within the limits of the instrumental survey, including the whole of the bar at its mouth, is nearly finished, and will be transmitted to the Chief of Engineers in a few days. All the information furnished by the survey having already become available, I deem it proper to submit this report at once, in order that the purpose for which the survey was ordered may not be unnecessarily delayed. The general direction of St. John's River from its mouth, situated in latitude 30° 20½′ north to Jacksonville, a distance of about twenty-five miles, is east and west. Above Jacksonville as far as Pilatka, one hundred and twenty-five miles from the mouth, it lies nearly north and south, being parallel with the main coast and about twenty miles from it.

"For nearly one hundred miles from its mouth it forms a wide sluggish sheet of water, more resembling a lagoon than a river," the distance from shore to shore in some places being fully five miles.

The currents in the river are apparently but slightly influenced by freshets, even during the rainy season, and where most active near the mouth, are without doubt principally due to the tidal wave.

The waters of the river are never turbid like those of the Mississippi, or like the Altamaha and Santee in certain seasons, and they do not, even when there is a conjunction of strong westerly winds and freshets, exert any considerable agency in the formation of the bar at the mouth of the stream, by the deposit of sediment brought down from the interior. The average velocity of the ebb current, when the river is most swollen, would doubtless bear a very considerable acceleration, without producing any injurious results by deposits. On the bar at the present time there is a minimum depth of seven feet of water at mean low tide, with an average rise and fall of 5.4 feet. After once passing the bar a vessel can carry, on the flood, from fourteen to fifteen feet of water to Jacksonville, where the rise and fall is only one foot. A depth of ten feet may be carried to Pilatka and eight feet to Lake George, while small steamers ply much higher up. The area of the water-way at quarantine, which is at the mouth of the river just within the point where it begins to widen out into the ocean, is 37,625 square feet, with a high-water width of 1,750 feet; while on the bar, estimated along its crest line or curve of

least soundings, from shore to shore, the water-way measures 177,941 square feet, with a width of 16,630 feet.

METHOD OF IMPROVEMENT BY STRAIGHTENING THE STREAM.

It was perhaps the freedom of the stream from sediment, and practically from all currents except those caused by the ebb and flow of the tide, taken in connection with the circumstance that there are short curves in the channel between Jacksonville and the mouth of the river, that suggested, some years ago, a method of improvement by staightening the water-way at those curves, in order to facilitate the inward, and consequently the outward flow of the tide. It was assumed that any device which should cause the tidal wave to ascend to a higher point on the river than it had ordinarily attained before, thereby increasing the volume of water flowing in over the bar, would proportionally increase the duration of high-water navigation, as well as the velocity and scouring effect of the retiring current, and would also enlarge the area of the water-way on the bar. But whether this enlargement of water-way would take place in the channel to such degree as would secure the desired depth of the water on the bar, or would be distributed principally over the shoals between the channel and the shore on either side, producing little useful effect where most needed, are questions surrounded with such doubt and uncertainty as to render this method of improvement inexpedient, in my judgment, until some other plan has been tried without adequate success. Moreover, the survey and examination just completed did not, for want of sufficient time, embrace within its limits those portions of the river which would require to be straightened, and I am not therefore prepared to submit estimates of the cost of this method of improvement. It does not, however, seem to promise any certain and permanent advantage to navigation on the bar, while upon the shoals and curves above the bar within the limit reached by the increased tidal wave it would doubtless prove beneficial.

IMPROVEMENT BY MEANS OF PIERS AT THE MOUTH.

The channel-way over the bar is subject to very great and sometimes sudden and apparently capricious changes in one or in all of the essential features of depth, direction, and position. To a close observer the causes of these changes admit of an easy and satisfactory solution. They depend almost entirely, for their extent and character, upon the force and direction of the wind. The only other varying cause, not recurring at regular intervals under some known law, like the tides, is the influence of freshets upon the current of the river. This, if not practically inappreciable, can have no important bearing upon any plan of improvement to be applied at the mouth of the river.

During the prevalence of strong westerly winds of considerable duration, the velocity of the ebb current is greatly increased, and it runs for seventeen or eighteen hours out of the twenty-four, and sometimes longer. The result is an increased depth of water in the channel on the bar, produced conjointly by the scouring effect of the increased outgoing current, and by preventing the deposition of sand thrown into momentary suspension by the waves of the sea. Under these circumstances the channel has been known to attain a depth of eight feet at mean low water; and whether any other change would be effected in a given case, would depend on whether the existing *direction* and *position* of the

channel were established mainly during the prevalence of westerly winds, or otherwise.

When the wind blows off the ocean other phenomena are observed. It is known from observation that, in the shallow portions of the waterway over the bar, that is, upon the shoals or spits which extend out from the main shore on either side, the outward current runs with less velocity than in the channel, and ceases with the commencement of the flood, or very soon after; also, that upon the north shoal, near the shore line, there is a strong eddy during the first quarter of the ebb, setting due south at the rate of one knot. In the channel-way the ebb current runs, according to the force and direction of the wind, from one and a half to three hours after the flood begins. Along shore outside the bar there is a current, not exceeding half a knot in mild weather, setting to the southward during the flood, and to the northward during the ebb; but these currents may be destroyed or even reversed by the wind.

During the prevalence of high northerly or northeasterly winds a current sets to the southward along the outer edge of the shoal, the force of the river ebb is deadened, and a portion of the sand thrown up by the waves of the ocean inside the sea buoy, and especially by the ceaseless breakers on the north spit, is deposited and remains in the channel. At the same time the sand set in motion by the waves on the south spit is carried to the southward. The natural results are that the channel way is moved to the southward with shallowed soundings, the extent of both elements of change depending greatly upon the force and duration of the wind. With strong southeasterly winds, on the contrary, the channel is forced to the northward, accompanied, as before, with a diminished depth of water. A plan of improvement which naturally suggests itself in the presence of these facts is, to confine the waters which now flow into the ocean over the shoals and through the bar channel dispersed over a water way 16,630 feet in width, so that they will be compelled to make their exit within narrower limits, and consequently with increased velocity, the object being to create an ebb current of sufficient force to scour out the channel to the requisite depth, and, of course, prevent the deposits which now take place under the influence of high, long-continued winds blowing toward the land.

It appears that this scheme could be applied with reasonable promise of success, by constructing a pier or breakwater along the north side of the channel, and in its general direction parallel thereto, extending from the shore to the existing bar, approaching the outer edge thereof as nearly as practicable.

A project of this character was discussed, and, I believe, recommended by a commission over fourteen years ago, but was never undertaken in consequence perhaps of its great cost, and some doubts of its feasibility entertained by those who proposed it. The same objections to it exist at the present time, and its estimated cost of $196,000 in 1854 would have to be increased to at least $300,000, to meet the advance in all kinds of material and labor. Moreover, no considerable benefit would be derived from the adoption of this project much short of its entire completion, and not within an expenditure of at least $200,000 to $225,000. For these reasons I cannot recommend this plan.

IMPROVEMENT BY CLOSING THE MOUTH OF FORT GEORGE INLET.

Dr. A. S. Baldwin, a citizen of Jacksonville, has for many years confidently advocated closing the mouth of Fort George Inlet, as offering a sure remedy for all the evils growing out of the inadequate depth of

water on St. John's bar. Dr. Baldwin's theory, if I understand it, rests upon the assertion, or perhaps the circumstance, that there is on each tide an interchange of waters in large volumes between St. John's River and Fort George Inlet; that the waters thus exchanged flow through swash channels, and otherwise over the north shoal, and not around by the main channel across the bar, and that while this flow is taking place from the river to the inlet, that is, during the ebb tide, it increases the outward current over the shoal, thereby still further diminishing the volume of water which would otherwise pass out by the main channel. As already stated, the flood current in the inlet begins with the flood tide or thereabouts, and from one and a half to three hours before the ebb current ceases in the river at the bar, and perhaps a short time before it ceases on the north shoal, and it may be, and probably is true, that during this interval a portion of the river waters flows out over the north shoal near the shore, and thence into the inlet. But I cannot concede the conclusion assumed by Dr. Baldwin, that if the mouth of the inlet be closed these waters would not continue to pass out over the north shoal and thence into the ocean, but would naturally and of necessity flow over the bar channel, thereby adding to the velocity and scouring effect of the ebb current. In my judgment, therefore, closing the inlet does not offer a certain or even a probable remedy for the evils complained of.

METHOD NOW PROPOSED, BY REPEATED DREDGING, OR RAKING ON THE BAR.

In my judgment, any project for improving the navigation at the mouth of St. John's River should be of a character to insure immediate results, proportional, within quite narrow limits, to the amount expended in its execution, and not requiring a large outlay of money to test the value of problematical devices. These considerations possess special importance at the present time, when the exercise of a rigid economy in every department of the general government is a necessity as well as a duty, and when all expenditures for public works should be based upon the most advantageous adaptation of means to an end. Other things being equal, that method is the best which will soonest afford the needed relief, especially if it be susceptible of fair and thorough trial at a moderate cost, and of prompt and entire suspension without loss or damage in default of adequate success. It is submitted that the simple plan of deepening the channel by repeated dredgings or rakings during the strongest stage of the ebb current, promising, as it does, at least a fair measure of success at comparatively small cost, should be first tried in preference to either of the projects hereinabove discussed. The peculiar formation of the bar favors the plan proposed, being very steep at its outer edge, so that the sand thrown into suspension by the repeated use of the rake or dredge, and borne along by the ebb current after each disturbance, would soon lose itself in deep water.

It is believed that a constant minimum depth of at least 10 feet at mean low water, with a width sufficient for the purposes of navigation, may be secured on the bar at a cost not exceeding $10,000 per year. This would give a depth of $15\frac{4}{10}$ feet at ordinary high water, and enable vessels drawing fully 14 feet of water to cross the bar, even in rough weather, without striking. With the ordinary swell of the ocean in mild weather $14\frac{1}{2}$ to 15 feet could be carried in with safety. Vessels of greater draught cannot reach Jacksonville.

A responsible party, now engaged in the towing business on St. John's

River, has expressed a willingness to undertake the work by contract upon the terms above named; that is, to secure and maintain for practical use an additional depth of three feet on the bar, for $10,000 a year, the payment to be strictly contingent on the successful execution of the agreement according to all its terms and conditions.

For the reasons thus briefly set forth I estimate that the expense of deepening the channel over the bar "so that it will answer the demands of commerce" will require an appropriation of $10,000, for the first year, and perhaps a somewhat less amount for each subsequent year, and that the merits of the method proposed for trial may be ascertained at an expenditure not exceeding $5,000.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Major of Engineers, Brevet Major General U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers U. S. A., Washington, D. C.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 3, 1869.

GENERAL: In compliance with the request of the Committee on Commerce of the Senate of the United States, on the 23d of July last, that a survey should be made with a view to obtaining estimates of the expense of deepening the channel at the mouth of the St. John's River, Florida, so that it will answer the demands of commerce, I transmit herewith the report of Brevet Major General Q. A. Gillmore, major of engineers, as a preliminary to a more full and complete report upon the subject. The map of the survey is not yet completed, nor have the requirements of the joint resolution of Congress of July 23, 1868, in reference to the amount of commerce to be benefited by the improvement asked for, been complied with. Copies of the map and statements in relation to commerce will be forwarded when received.

The project proposed by General Gillmore for increasing the depth of water on the bar from 7 to 10 feet, at mean low water, by repeated dredging or raking, seems to meet the present wants of commerce and navigation; and as "a responsible party" has expressed "a willingness to undertake the work by contract upon the terms above named, "that is, to secure and maintain" for practical use an additional depth of three feet on the bar for $10,000 a year, the payment to be strictly contingent on the successful execution of the agreement according to all its terms and conditions," I see no objection to making an appropriation of $10,000, to be expended subject to the conditions above named. The method of improving the depth of water on the bar should be considered as purely experimental; and if it be successful it will only afford temporary relief, for experience has shown that the channel through the bar is not fixed, but is ever changing, depending upon the force and directions of the storms; even apart from the consideration of the effects of storms, the operation of deepening must be continuous to maintain the depth when once secured.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Major General J. M. SCHOFIELD,
Secretary of War.

K 1.

UNITED STATES ENGINEER OFFICE,
Corner Houston and Greene Streets, N. Y., February 8, 1869.

GENERAL: In reply to letter from headquarters Corps of Engineers dated January 30, ultimo, upon the subject of my recent report on the St. John's River improvement, I have the honor to make the following statement as supplementary thereto, showing "to what extent the general commerce of the country will be promoted" by the improvement in question—that is, by increasing the depth of water on the St. John's bar to such degree as will enable vessels drawing fourteen to fifteen feet to pass in all ordinary weather.

My application to the Bureau of Statistics for published reports containing the required information having met with no response during an interval of six days, I deem it proper to wait no longer, but to submit what reliable data I have been able to collect in this city from official and other sources.

There is considerable demand for Florida lumber in the West Indies, in Brazil, and in Europe, which it is always difficult and sometimes impossible to supply at paying rates from the St. John's district, for the reason that vessels carrying large freights cannot engage in the business. For the coastwise trade from the same cause, there is a difference of from one to two dollars per thousand in the freights, in favor of Brunswick and Savannah in their competition with the lumber trade of the St. John's region.

A vessel of three hundred and thirty tons burden, which is about the average capacity of those engaged in the St. John's River trade, cannot compete successfully with one capable of carrying five hundred tons in freighting lumber to foreign or distant home ports.

The total number of vessels entering and leaving St. John's River during the four months ending on the 31st day of July, 1867, is officially reported as follows. No other trustworthy data of the same character for a longer period of recent date have been obtained:

Entered in four months.

Coastwise trade—87 vessels, with an aggregate tonnage of 28,529.
Foreign trade—3 vessels, with an aggregate tonnage of 224.

Cleared in four months.

Coastwise trade—95 vessels, with an aggregate tonnage of 31,887.
Foreign trade—9 vessels, with an aggregate tonnage of 1,256.

It is presumed from the information gathered that the small vessels engaged in the foreign trade carried oranges exclusively, and that the others entered light as a general thing, and cleared with a cargo of lumber. At the same rate, excluding the small vessels, the aggregate for one year would be two hundred and sixty-one vessels entered, with an aggregate tonnage of eighty-five thousand five hundred and eighty-seven tons, and two hundred and eighty-five vessels cleared, with an aggregate tonnage of ninety-five thousand six hundred and sixty-one tons. It is the opinion of the lumber-mill owners on the St. John's River, which should be received with due caution, that an increase of the depth of water on the St. John's bar to fourteen and one-half to fifteen feet at ordinary high tide, would almost immediately result in an increase of thirty to fifty per cent. in the foreign and domestic lumber trade of that region.

There are at the present time in operation in the river eight or ten saw-mills, capable of producing forty to fifty million feet of lumber per

annum. The yield of one of these mills during the year 1868 was about six million feet, of which five million were shipped to home and foreign ports. and the balance consumed in the neighborhood. This mill is now running at the rate of twelve million feet per annum, on orders for home trade.

The lumber is valued at an average of twenty dollars per thousand feet board measure, delivered at the mills, at which rate an annual product of forty million feet would be worth eight hundred thousand dollars before shipment. One and one-quarter per cent. of this sum amounts to ten thousand dollars, which is the estimated yearly cost of keeping the bar channel dredged to the depth contemplated in my report of the 29th ultimo, so that "with the ordinary swell of the ocean in mild weather fourteen and one-half to fifteen feet could be carried in with safety."

The lumber produced on the St. John's River belongs to the class known as deal, and is subject to neither manufacturers' tax nor export duty. Besides the lumber trade there is no other branch of local industry which demands or would justify any expenditure by the general government to secure improved facilities of navigation.

Under these circumstances it may perhaps be questioned whether the parties who would be principally and almost exclusively benefited by the improvement under consideration should not be required to contribute to its accomplishment. Should additional information upon this subject be received from the Bureau of Statistics, or from the collector of customs at Jacksonville, to whom application has also been made, it will be forwarded without unnecessary delay. I inclose herewith a written proposal (copy) from Mr. Charles H. Campbell to dredge the bar channel "and keep it dredged to the depth of fifteen feet at high tides, so that vessels at any fair state of weather, drawing fifteen feet, can pass over the same with safety," for "the sum of ten thousand dollars per year."

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Major of Engineers, Brevet Major General U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army, Washington D. C.

NEW YORK CITY,
January 29, 1869.

GENERAL: Having been some time employed in towing on the St. John's Bar, State of Florida, and it having come to my notice that for some time back the United States government have been engaged in surveying the same for the purpose of improving the depth of water thereon, I would respectfully offer your department to dredge this bar and keep it dredged to the depth of fifteen feet at high tides, so that vessels at any fair state of weather drawing fifteen feet can pass over the same with safety.

Should this proposition meet with encouragement from your department, I will further offer to give bonds to the United States government to fulfill and carry out this proposition to the letter, the United States paying for the same the sum of ten thousand dollars per year.

I am, general, most respectfully, yours, &c.,

CHARLES. H. CAMPBELL,
118th St., Harlem, 6th house west of Third Ave., New York City.

Major General Q. A. GILLMORE,
Corps of Engineers United States Army.

APPENDIX L.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, July 15, 1869.

SIR: I have the honor to submit the following annual report for the fiscal year ending June 30, 1869, for the "improvement of the Falls of the Ohio."

On the 4th of August, 1868, I received the department letter of the 31st of July, 1868, informing me that the sum of $85,000 had been allotted toward the construction of the two dams recommended by me, for the improvement of the Falls of the Ohio, and I was directed to proceed at once to carry on the work.

I was further instructed, by department letter of the 27th of August, 1868, that none of this money could be expended upon the Indiana side of the river, nor in view of such work at any future day, but that it was solely applicable to work incident to the extension of the Louisville and Portland Canal.

On the 22d of August, 1868, for certain reasons, mentioned in my communication, and in my annual report on the survey for a ship canal around the Falls of the Ohio, for the fiscal year ending June 30, 1868, I applied for and received permission to substitute a crib dam across the Ohio River at the crest of the falls, in place of the masonry dam recommended by me at that point, in my special report on the survey for a ship canal around the Falls of the Ohio, dated February 8, 1868.

In accordance with the above, I at once reorganized my party, and commenced the survey and soundings necessary to determine accurately the best lines for the dams proposed by me.

In consequence of the continued rises in the river, and consequent high water, these operations were not concluded until early in November, 1868. It was then too late to hope for any work to be done during that season, and I therefore reduced my party to a minimum, and during the winter and spring, leisurely and carefully completed the general drawings for the upper dam, and the working and detailed drawings for its different parts; advertised for proposals; awarded contracts for the material and labor to be used and employed in its construction, and received and guarded the material.

Nearly all of the lumber and timber, and all of the iron, has been received, and the contractor for the work and for other material has commenced operations. I made no arrangements to commence work on the lower dam, because the amount of money allotted would not warrant it, and also, because its construction before the actual extension of the Louisville and Portland Canal would be very injudicious.

The construction of the upper dam before said extension is completed will be an obstruction to navigation at certain stages, for boats too large to pass through the old locks, which are still in use, and is another reason, in addition to the very many already given by me, in my previous reports, and by officers who have treated this subject before me, why the proper amount of money necessary to enlarge the body of the old canal, and complete the branch to the new locks, should at once be appropriated.

On the 15th of May, 1869, I received the department letter of the 12th of May, 1869, informing me that $180,000 additional had been allotted to the improvement of the Falls of the Ohio, and on the 31st of May, 1869, the department letter of the 27th of May, 1869, authorizing me to expend the whole amount of this new allotment, and whatever balance

there might be left of the first allotment, after the upper dam was built, in the enlargement of the Louisville and Portland Canal. I had already come to the conclusion, long before receiving this authority, and I was sustained in my conclusions by the great experience of the directors of the Louisville and Portland Canal, that the most important thing was, first to enlarge and improve the entrance to the head of the canal as far as the upper guard gates, and whatever balance there might then be left to employ in opening the new locks into the main trunk of the canal.

It happens every year at certain stages of the river, that boats in attempting to enter the canal from above are drawn on the rocks.

To avoid this to a certain extent, the company some years since constructed an apron dam about 630 feet long, commencing at the head of the outside wall of the canal and inclining northwardly. (See sheet 1, survey for a ship canal around Falls of the Ohio, on file in your office.) This dam I propose to continue in its present direction about 1,200 feet, and to raise it, throughout its whole length, about two feet, but diminishing its width to only ten feet.

All the rock inside of this dam shall be removed, so that nowhere shall there be less than six feet of water when the dam across the river is completed.

On the inner, or Kentucky, bank of the canal, I propose to build a substantial retaining wall, from the guard gates up to about Eighth street, Louisville, Kentucky, and on the outer bank a similar wall, from the upper guard gates to the pier head at the entrance.

I transmit herewith a sketch showing the proposed work, as stated above. Complete drawings of the whole work will be transmitted as soon as they can be completed.

In order to avoid any possible damage to boats entering the canal, from striking these stone retaining walls, I propose to suspend wooden fenders from their tops, at proper intervals.

I am told that I may expect some difficulty in getting a foundation for the wall on the inner or Kentucky bank, and will therefore, as soon as the stage of the water permits, make the necessary borings and examinations.

As soon as I can ascertain with some degree of certainty what the above work at the head of the canal will cost, I will immediately take steps to expend the balance in prosecuting the excavation of the branch from the new locks to the main trunk.

The total amounts required for the completion of this work, as already reported in my last annual report on the survey for ship canal around the Falls of the Ohio, are as follows, viz:

For Louisville and Portland Canal extension	$933,500 00
For two dams and one lock	310,000 00
Total	1,243,500 00
Total already appropriated	265,000 00
Total still to be appropriated	978,500 00

Of this amount about $450,000 could, in addition to the amount now on hand, be profitably expended during the fiscal year ending June 30, 1871.

This work is located in the third collection district of Kentucky.

The nearest port of entry is Louisville, Kentucky.

The amount of revenue collected at this port of entry, during the fiscal year ending June 30, 1869, was $154,113 40.

The commerce and navigation of the Mississippi River and all of its branches would be benefited by the completion of this work.

I have taken the following steps to carry on this work during the coming season, viz: I have contracted for the entire work and material required to construct the dam across the Ohio River, along the crest of the falls, in front of Louisville, Kentucky. I have purchased all the lumber, timber, and iron, and have made agreements for the work to be done in extending and raising the apron dam at the head of the canal as above stated.

I have advertised for bids for the rock excavation required inside this dam, as above stated, and I will commence work on the walls from the upper guard gates, upward, as above stated, as soon as I can possibly do so intelligently.

Abstract A shows the bids received for lumber and timber for dam.

Abstract B shows the bids received for iron bolts, spikes, and wedges for dam.

Abstract C shows the bids on the two different occasions for work on dam.

Abstract D shows the name of the parties to whom the different contracts were awarded.

All of the above abstracts are hereto annexed.

The amount of cash received for this work during the fiscal year ending June 30, 1869, is	$40,000 00
The amount expended during the same period is	26,054 47
The amount of appropriation available June 30, 1869, was	225,000 00
The amount required for the fiscal year ending June 30, 1871, is	450,000 00

All of which is respectfully submitted.

G. WEITZEL,
Major Corps of Engineers, Bvt. Maj. Gen. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brigadier General and Chief of Engineers,
Office of Chief of Engineers, Washington, D. C.

A.—*Abstract of bids for furnishing 636,000 feet, board measure, of white oak lumber and timber for dam at the Falls of the Ohio, opened by Brevet Major General G. Weitzel, major Corps of Engineers, on January 25, 1869, at 12 m.*

Name and residence of bidders.	Amount bid per M feet, board measure.
Merwin Prindle, Madison, Ind	$34 50
Whitney & Shannon, Madison, Ind	33 00
Ray & Connell, Louisville, Ky	32 00
S. and J. V. Johnston, Henry County, Ky	30 00
Caldwell & Robinson, Madison, Ind	29 70
Cook & Henry, Kittanning, Penn	29 00
Barton, Gibbs, & Co., Portsmouth, Ohio	28 75
Alexander Bacon & Co., Louisville, Ky	27 00
Stuart & Barmore, Jeffersonville, Ind	26 90
Howard & Co., Jeffersonville, Ind	26 50
Jonas Butterfield, Cincinnati, Ohio	26 50
Glover & Sample, Jeffersonville, Ind	24 90
D. C. Hill, New Albany, Ind	24 90

Respectfully submitted.

G. WEITZEL,
Major Corps of Engineers, Brevet Major General U. S. A.

B.—*Abstract of bids for furnishing iron bolts, spikes, and wedges, to be used in the construction of a dam at the crest of the Falls of the Ohio, opened March 17, 1869, at 12 m., by Brevet Major General G. Weitzel, major Corps of Engineers.*

Name and residence of bidders.	PRICE PER POUND.					
	13-inch bolts.	Rag bolts.	16-inch spikes.	9-inch spikes.	6-inch spikes.	Wedges.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Lewis, Oliver & Phillips, Pittsburg, Pa	5.7	5.20	5.70	5.45	5.70	9
William B. Scaife, Pittsburg, Pa	8	8	6½	6½	6½	8
Edward Kaylor, Pittsburg, Pa	6	7½	7	7	7	20
Everson, Preston & Co., Pittsburg, Pa	8½	8½	8¾	......	......	9
James White, Cincinnati, Ohio	6¾	6½	5½	5½	5⅜	13
Miami Machine Works, Cincinnati, Ohio	7½	7½	7½	7½	7½	7½
J. A. Pomeroy, Cincinnati, Ohio	6½	6½	8¼	5¼	5¼	5
Charles Ratcliffe & Co., Cincinnati, Ohio	5¼	5¼	5⅜	5¼	5⅜	5¾
Joseph Slusser, Cincinnati, Ohio	7¼	7¼	7¼	7¼	7¼	7¼
J. B. Green & Bro., Cincinnati, Ohio	7	6¼	5½	5½	5¼	13
D. C. Hill & Co., New Albany, Ind	7	7	7	7	7	7
S. S. Marsh, New Albany, Ind	6½	6½	6½	6½	6½	6½
Dennis, Long & Co., Louisville, Ky	6⅞	6¾	6⅞	6½	6½	15
Julius Barbaroux, Louisville, Ky	6	6	5¾	6½	7½	12
Thomas Meikle & Co., Louisville, Ky	6.23	6.23	6.23	6.23	6.23	6.23
Ainslee, Cochran & Co., Louisville, Ky	6½	6½	6½	6½	6½	6½
Francis H. Smith, New York	7¾	6¾	6¼	6¾	7¾	10½
A. P. Dustin, Jeffersonville, Ind	7	7	7	7	7	7
Norway Iron Manufacturing Company, Wheeling, West Va	6	6	6	6	6	6

Respectfully submitted.

G. WEITZEL,
Major Corps of Engineers and Brevet Major General U. S. A.

C.—*Abstract of bids for building dam at the crest of the Falls of the Ohio, opened by Brevet Major General L. Weitzel, major Corps of Engineers, on April* 19, 1869, *and May* 17, 1869.

Name and residence of bidders.	Amount bid per M feet, board measure, of lumber and timber.
McAtee & Cassilly Louisville, Ky	$90 00
D. C. Hill, New Albany, Ind	85 00
McKenzie, Robinson & Geiger, Louisville, Ky	85 00
M. P. Wood, Louisville, Ky	80 20
Hugh Donahue, Louisville, Ky	80 00
Hay, Myer & Broadhead, Louisville, Ky	79 25
M. Hariland, Circleville, Ohio	78 00
Robert N. McClellan, Louisville, Ky	74 85
George M. Sauman, Philadelphia, Pa	48 00
Bratton, Bird & Borres, Louisville, Ky	43 00
BIDS OPENED ON MAY 17, 1869, at 12 M.	
McAtee & Cassilly, Louisville, Ky	75 00
R. McKenzie, Louisville, Ky	69 85
Hay, Myer & Broadhead, Louisville, Ky	69 29
I. M. Bralton & Co., Fort Wayne, Ind	49 95
George W. Seward & Son, Jeffersonville, Ind	46 33
Michael Hariland, Circleville, Ohio	44 75
Shipley & Loyal, Louisville, Ky	40 00

Respectfully submitted.

G. WEITZEL,
Major Corps of Engineers and Brevet Major General U. S. A.

D.—*Abstract showing the names of parties to whom contracts have been awarded during the fiscal year ending June* 30, 1869, *by Brevet Major General G. Weitzel, major Corps of Engineers, on account of the improvement of the Falls of the Ohio.*

Name and residence.	Nature of contract.
D. C. Hill, New Albany, Ind	Furnishing white oak lumber and timber for dam at crest of the Falls of the Ohio.
Lewis, Oliver & Phillips, Pittsburg, Pa	Furnishing iron bolts, spikes, and wedges for same.
Shipley & Loyal, Louisville, Ky	Construction of dam at the crest of the Falls of the Ohio.

Respectfully submitted.

G. WEITZEL,
Major Corps of Engineers, Brevet Major General U. S. A.

L 1.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., April 15, 1869.

SIR: In the act of July 25, 1868, making appropriations to supply deficiencies, &c., one million and a half dollars were appropriated for the "repair, preservation, extension, and completion of certain public works on rivers and harbors," to be expended under the direction of the Secretary of War, with a proviso authorizing expenditure from this appropriation upon any of the works enumerated in a bill which passed the House of Representatives June 30, 1868.

In compliance with the requirements of this proviso an allotment of

$85,000 was made from this appropriation for the improvement of the Falls of the Ohio. A portion of this sum is now being expended in the construction of a dam at the head of the falls.

The improvement of the navigation at the Falls of the Ohio is perhaps of greater importance than any other western river improvement, and in the allotment of the two million dollars just appropriated for rivers and harbors, the question arises, in what manner a portion of this sum can best be applied to this object, and whether any part of it can be expended in the completion of the enlargement of the Louisville and Portland Canal.

The history and present condition of this work are briefly as follows:

It was completed in 1830 by a company chartered by the State of Kentucky, the United States owning at that time 2,335 shares and individuals 3,665. In 1831 the government received 567 additional shares in lieu of dividends, making in all 2,902.

In 1842 the State of Kentucky amended the charter of the canal company so as to authorize the president and directors, with the assent of the stockholders, to sell the shares belonging to individuals, either to the United States, to the State of Kentucky, or to the city of Louisville, for the purpose of eventually making the canal free of tolls; for which object the president and directors of the company were authorized to apply the net income of the canal to the purchase of the stock. This act further provided that the shares so purchased should be held in trust and transferred to the United States upon the condition that only such tolls be levied as would be sufficient to pay expenses, keep the canal in repair, and make all necessary improvements, so that the canal should fully answer the purposes of its establishment.

From 1842 to 1855 the net income of the canal was devoted, without objection on the part of the United States, to the purchase of the stock held by individuals, and the United States at that time became owners of all but five shares of the stock, at a cost of $1,709,262. These five shares were retained, with the assent of the United States officers, and are now held by five individuals who still constitute the Louisville and Portland Canal Company, and who are, under the act of 1842, the trustees of all the stock purchased from individual owners for the United States, as provided in the said act.

By a resolution of Congress, of May 24, 1860, the president and directors of the company were authorized to enlarge the canal, and to construct a branch canal, using therefor the *revenues and credits of the company*, but they were prohibited from using or pledging the faith or credit of the United States for said enlargement, &c. This resolution contained a further provision that when "said canal is enlarged and its branch canal completed, and the cost of the improvement paid for," no more tolls shall be collected than sufficient to keep the canal in repair and pay expenses. The State of Kentucky had previously authorized the enlargement, and had also provided for its withdrawal from all control of the canal upon the formal acceptance by the United States of the canal, upon the conditions of the act of 1842.

At this time (1860) the canal company was entirely out of debt and had cash on hand amounting to $131,764. This enlargement and extension were then begun, and stopped in 1866 for want of funds, after an expenditure of $1,825,403.

The present indebtedness of the company is $1,567,000, in bonds due respectively in the years 1871–'76–'81–'86. It had in December, 1867, a cash balance on hand of $217,453.

The United States are virtually the owners of the canal, and the work of

enlargement being still unfinished, it now becomes a question whether, in view of the terms of the resolution of Congress of 1860, any portion of the appropriation for rivers and harbors can be applied to the work of enlargement, or in any manner toward the improvement of this canal until the five individual share-holders transfer to the United States all the rights, &c., they now hold in trust. Although the subject has been frequently brought to the attention of Congress, yet no act or resolution has ever been passed specifically accepting the conditions of the Kentucky act of 1842, and authorizing or directing any officer of the United States to receive the bonds held by the trustees, and assume the control of the canal.

But these individual share-holders now composing the Louisville and Portland Canal Company deem it their duty not to surrender their trust unless the United States assume the indebtedness of the company, which up to this time they have not done, and virtually refuse to do.

While this anomalous condition of things continues, (these five individuals holding United States property in trust by authority of the legislature of a State, and controlling public property which has cost millions, and still unable to complete the canal improvement without increasing its debt,) the heavy tax upon the commerce of our most important rivers is continual, and the navigation of the Ohio is most seriously obstructed.

The wants of this commerce imperatively demand the completion of this enlargement, to do which, the only practicable mode appears to be annual appropriations from Congress until the work is finished, the tolls of the canal being used for the payment of working expenses and the absorption of its debt, which they are adequate to.

After a careful examination and consideration of the whole subject, I am decidedly of opinion that an allotment of some portion of the recent appropriation for rivers and harbors to the enlargement of the canal may properly be made, and I therefore recommend it.

If this recommendation be approved, a specific sum will be named for this work in a report recommending to your consideration a plan of distribution of the recent appropriation, which will be presented as soon as all the information called for from the officers in charge of river and harbor improvements is received.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General, and Chief of Engineers.

HON. JOHN A. RAWLINS,
Secretary of War.

L 2.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, July 15, 1869.

SIR: I have the honor to submit the following annual report for the fiscal year ending June 30, 1869, for the improvement of the Tennessee River:

On the 4th of August, 1868, I received the department letter of the 31st of July, 1868, informing me that the sum of $85,000 had been allotted toward the improvement of the Tennessee River between Chattanooga, Tennessee, and Decatur, Alabama, and Florence, Alabama, and its

mouth. I accordingly advertised for proposals for making the improvements between these points, reported as necessary to be made in my special report on the "survey of the Tennessee River," dated February 20, 1868, and awarded the work at "Ross's Tow-head," "Burroughs's Bar," "Tumbling Shoals," "Kelley's Shoals," and "Gunter's Bar," to the lowest bidder.

Deeming all the bids at the other points too high, I re-advertised for bids on the "Tumbling Shoals," the "Suck," and "Boiling Pot," in the Upper Tennessee River, and all the points in the Lower Tennessee River specified in the above-mentioned report, and then awarded the contract to the lowest bidder.

In the course of the winter, as I became better acquainted with the subject, I became convinced that, as during the season in which I made the survey there had been an unusually low stage of water, several of the obstructions enumerated in the Upper Tennessee River in my report were really unimportant, and that all the money to be expended on the Upper Tennessee River should be expended on the "Tumbling Shoals," the "Suck," and "Pot."

The suggestion made to the department in accordance with this view was approved. All the contracts for work on this river having been, with the approval of the Chief of Engineers, assigned to one person, I obtained from him a voluntary relinquishment of his contract for the other points on the Upper Tennessee, on condition that the whole amount thus made available should be expended on the three points above mentioned.

He has been prosecuting his work as vigorously as the stage of the water would permit, and has made considerable progress in the improvement of the "Suck," and, with a favorable season, hopes to complete his contract this year.

On the 15th of May, 1869, I received the department letter of the 12th of May, 1869, informing me that $40,500 additional had been allotted to the improvement of the Tennessee River. With this amount additional, I expect to be able to make a complete improvement of the portions of the river above designated, and it is my intention to prosecute this work during the coming season as vigorously as possible, completing first the work on the Upper, and then beginning on the Lower Tennessee River.

The total amount required for the completion of this work, as already reported in my last annual report on the survey of the Tennessee River, I estimate as follows:

To improve the river from its mouth to Florence, Alabama, and from Decatur, Alabama, to Chattanooga, Tennessee, $130,000.

To enlarge and repair the existing canal, from Lamb's to Campbell's Ferries, $1,500,000.

In order to enable me to get material for a proper estimate for canals around the Elk River and the Little Muscle Shoals, I recommend that another survey be made of these points. I estimate that this survey, properly made, would cost $10,000.

The total amount therefore required, as far as I now can state, is $1,640,000.

The amount that has been appropriated for this work is $125,500; leaving $1,514,500 still to be appropriated.

During the fiscal year ending June 30, 1871, the following amounts can be profitably expended:

1. To enlarge and repair the existing canal, from Lamb's to Campbell's Ferries $500,000 00
2. To improve the river, from its mouth to Florence, Alabama 500 00

3. To resurvey the river from Brown's Ferry to Florence, Alabama	$10,000 00
Total	510,500 00

I am unable to give the number of the collection districts through which the river passes.

The nearest port of entry is Louisville, Kentucky.

The amount of revenue collected at this port during the fiscal year ending June 30, 1869, was $154,113 40.

The commerce and navigation of the Mississippi River and all of its tributaries would be benefited by the completion of this work.

Abstract A, herewith annexed, shows the bids received on both occasions, for improving the various points.

Abstract B, herewith annexed, shows the names of the persons to whom the different contracts were awarded.

The amounts of cash received for this work during the fiscal year ending June 30, 1869, are	$60,000 00
The amount expended during the same period	15,209 69
The amount of appropriation available June 30, 1869, was	65,500 00
The amount requisite for the fiscal year ending June 30, 1869	510,500 00

All of which is respectfully submitted.

G. WEITZEL,
Major Corps of Engineers and Bvt. Maj. Gen. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers,
Office of the Chief of Engineers, Washington, D. C.

A.—*Abstract of bids for the removal of the obstructions of the Tennessee River, opened on Wednesday, September 9, 1869, by Brevet Major General G. Weitzel, major Corps of Engineers, at Louisville, Kentucky.*

Name of bidder.	Residence.	Bids.
Charles J. De Graw....	Fulton, N. Y......	Ross's Tow-head: 940 cubic yards rock excavation, at $3 per cubic yard; 940 cubic yards wing-dam, at $1 50 per cubic yard; 60 cubic yards wing-dam, at $2 per cubic yard. Lookout Shoals: 465 cubic yards wing-dam, at $2 per cubic yard. Burroughs's Bar: 900 cubic yards wing-dam, at $2 per cubic yard; 335 cubic yards sandstone excavation, at $3 per cubic yard. Tumbling Shoals: 150 cubic yards boulder excavation, at $3 50 per cubic yard; 10 0cubic yards sand stone excavation, at $3 per cubic yard; 75 cubic yards boulder excavation, at $3 50 per cubic yard; 12 cubic yards sandstone excavation, at $3 50 per cubic yard; capstan and fixtures, $500. Boiling Pot: 5,000 cubic yards rock excavation, at $2 25 per cubic yard. The Skillet: 25 boulders to be excavated, at $5 per cubic yard; 746 cubic yards wing-dam, at $2 per cubic yard; capstan and fixtures, $400. Kelbey's Shoals: 2,666 cubic yards wing-dam, at $2 50 per cubic yard.
R. R. & N. G. Dodge...	Cleveland, Ohio....	Long Island: 922 cubic yards riprap in wing-dam and retaining wall, at $2 25 per cubic yard, and 450 cubic yards rock excavation, at $3 per cubic yard. Widow's Bar: 3,200 cubic yards riprap in wing-dam, at $2 per cubic yard, and 280 cubic yards solid rock excavation, at $3 25 per cubic yard. Larkin's Tow-head: 2,133 cubic yards riprap in dam, at $2 25 per cubic yard. Mink Creek Shoals: 3,200 cubic yards riprap in dam, at $2 per cubic yard. Buck Island: 1,111 cubic yards riprap in dam, at $2 per cubic yard; 160 cubic yards rock excavation, at $4 per cubic yard. Town Island: 23 cubic yards boulder excavation, at $5 per cubic yard. Gunter's Bar: 470 cubic yards rock excavation, at $4 per cubic yard. Gunter's Reef: 300 cubic yards rock excavation, at $3 50 per cubic yard. Flint River Tow-head: 533 cubic yards riprap in wing-dam, at $2 25 per cubic yard. Whitesburg Shoals and Reefs: 2,963 cubic yards riprap in wing-dam, at $2 25 per cubic yard; 37 cubic yards boulder excavation, at $5 per cubic yard; 500 cubic yards limestone excavation, at $3 25 per cubic yard.
Abel Kisterson	Chattanooga, Tenn.	Ross's Tow-head: 940 cubic yards rock excavation, at $4 per cubic yard; 940 cubic yards wing-dam, at $1 50 per cubic yard; 60 cubic yards wing-dam, of excavated material, at $2 50 per cubic yard.
John L. Divine.........	Chattanooga, Tenn.	Tumbling Shoals: Rock excavation, at $8 50 per cubic yard. Boiling Pot: Rock excavation, at $3 per cubic yard. Burroughs' Bar: Rock excavation, at $8 50 per cubic yard. The Suck: Removing the rock in middle wall, at $3 per cubic yard; the solid rock excavation, deepening old canal, at $8 per cubic yard; loose rock excavation from Boulder Bar, at $2 per cubic yard.
J. H. Dennis and H. Carlisle.	Louisville, Ky.....	Ross's Tow-head, Lookout Shoals, Burroughs' Bar, Tumbling Shoals, the Suck, Boiling Pot, the Skillet, Kelby's Shoals, Long Island, Widow's Bar, Larkin's Tow-head, Mink Creek Shoals, Buck Island, Town Island, Gunter's Bar, Gunter's Reef, Flint River Tow-head, Whitesburg Reef and Shoals, Seven Mile Island, Colbert Shoals to Bee Tree Shoals, Bear Creek Shoals, Big Bend Shoals: the stone excavation at all these points, at $4 90 per cubic yard; and the riprap work, at same points, at $3 75 per cubic yard; capstan and setting, $450; cribbing per log, set in complete, $30 per M, board measure.

Respectfully submitted.

G. WEITZEL,
Major Corps of Engineers, and Bvt. Maj. Gen. U. S. A.

B.—*Abstract showing the names of parties to whom contracts have been awarded during the fiscal year ending June 30, 1869, by Brevet Major General G. Weitzel, major Corps of Engineers, on account of the improvement of the Tennessee River.*

Name.	Residence.	Nature of contract.
Charles J. De Graw....	Fulton, N. Y.......	Removing obstructions at Ross's Tow-head, Burroughs's Bar, Tumbling Shoals, and Kelly's Shoals.
R. R. & N. G. Dodge...	Cleveland, Ohio...	Removing obstructions at Gunter's Bar.
J. H. Dennis............	Louisville, Ky.....	Removing obstructions at the Suck, Boiling Pot, Seven Mile Island, Buck Island, Colbert Shoals to Bee Tree Shoals, (inclusive,) Bear Creek Shoals, & Big Bend Shoals

Respectfully submitted.

G. WEITZEL,
Major Corps of Engineers, and Bvt. Maj. Gen. U. S. A.

Abstract of bids for removing obstructions of the Tennessee River, opened October 5, 1868, at 12 m., by Brevet Major General G. Weitzel, major Corps of Engineers.

Name of bidder.	Residence.	Bids.
J. H. Dennis............	Louisville, Ky......	Suck: 1,250 cubic yards loose rock excavation, at $1 15 per cubic yard; 1,444 cubic yards solid rock excavation, at $3 75 per cubic yard; 7,000 cubic yards loose rock excavation, at 75 cents per cubic yard. Boiling Pot: 5,000 cubic yards solid rock excavation, at $1 50 per cubic yard. Seven Mile Island: 175 cubic yards solid rock excavation, at $3 75 per cubic yard; 3,636 cubic yards of riprap dam, at $2 25 per cubic yard. Buck Island: 6,611 cubic yards riprap dam, at $2 25 per cubic yard; 1,110 cubic yards riprap wall, at $2 25 per cubic yard. Colbert Shoals to Bee Tree Shoals, inclusive: 250 cubic yards rock excavation, at $3 75 per cubic yard; 25 cubic yards rock excavation, at $3 75 per cubic yard; 2,000 cubic yards boulder excavation, at $2 25 per cubic yard; 2,384 cubic yards riprap dam, at $1 20 per cubic yard; 1,060 cubic yards rock excavation, at $3 75 per cubic yard; 50 cubic yards boulder excavation, at $3 per cubic yard. Bear Creek Shoals: 711 cubic yards riprap dam, at $2 25 per cubic yard. Big Bend Shoals: 150 cubic yards boulder excavation, at $3 per cubic yard.
John L. Divine	Chattanooga, Tenn.	This party was the only one bidding on the above specified work besides J. H. Dennis, and his bids for the work were much higher than those of Mr. Dennis. His proposals have been lost or mislaid and cannot be found.

Respectfully submitted.

G. WEITZEL,
Major Corps of Engineers, Bvt. Maj. Gen. U. S. A.

L. 3.

UNITED STATES ENGINEER OFFICE,
Louisville, Kentucky, March 1, 1860.

SIR: I have the honor to enclose herewith a copy of a letter received by me to-day from Mr. W. B. Garr, superintendent of the Tennessee River Improvement..

I believe, too, now, that it would be better to expend the money on the Suck, Pot, and Tumbling Shoals, and let Ross's Tow Head, Burroughs's Bar, and Kelley's Shoals, remain as they are for the present. An in-

creased knowledge gained of the subject leads me to this change of opinion. But I have already made a contract with Mr. Charles De Graw, of Fulton, New York, to remove the obstructions at Ross's Tow Head, Burroughs's Bar, and Kelley's Shoals; he has not, however, yet done a thing towards executing his contract.

Now, what I wish to know is, whether I can annul the said contract, if De Graw agrees to it. I believe he would agree to it. I could then expend that money on the three points mentioned.

I desire to know, also, whether the general commanding the corps approves of this change, if it can be done.

I am, sir, very respectfully, your obedient servant,

G. WEITZEL,
Maj. Corps Engineers, Bvt. Maj. General U. S. A.

Brig. Gen. and Bvt. Maj. Gen. A. A. HUMPHREYS,
Commanding Corps of Engineers,
Headquarters Corps of Engineers, Washington, D. C.

OFFICE SUPERINTENDENT TENNESSEE RIVER IMPROVEMENT,
Chattanooga, Tennessee, February 26, 1869.

SIR: I have the honor to submit the following suggestions in regard to the improvement of the upper river for your consideration.

I desire, if possible, to have as much work concentrated on the Suck and Pot as will entirely remove the obstructions at those points, and that in view of the prosession of a dredge by the present contractor, as much of the work be capable of execution by the dredge as possible, in order to avoid the risk of interruption or failure by the recurrence of a season like the one just over, in which there were not altogether two months of good weather for working upon low water obstructions.

I would recommend the transfer of the work to these points from Ross's Tow Head, Burroughs's Bar, and Kelley's Shoals, for the following reasons:

During the past year Ross's Tow Head, Burroughs's Bar, and Kelley's Shoals, have been navigable at all times. When the survey of the river was made, in 1867, the water was lower than it had been for ten years, and many points were noted as obstructions, among which were those just named, which in years of ordinary stages of water are no obstacle to navigation.

The only difficulties encountered by steamboat men in 1868, in the upper river, were at Tumbling Shoals, the Suck, and the Pot; Tumbling Shoals, an obstruction at low water. The Pot is an obstruction at high and ordinarily high water, while the experience of the past fall and winter satisfies me that the Suck offers the most serious obstacles to navigation in the whole river above Muscle Shoals. So serious an obstruction has it been in the past winter that boats from north Alabama, intended to run to Chattanooga, have been obliged to discharge their freight at Bridgeport, Alabama, on account of the difficulty and expense of passing the Suck, and at most of this time the Tumbling Shoals was no impediment to navigation.

The original estimate for the Suck was for 9,690 cubic yards; 7,000 cubic yards of this quantity coming off the boulder bar. This estimate was based mainly upon my observations at the extreme low water season of 1867; as for its character at ordinary high stages, (that is, when there are four or five feet of water on the boulder bar,) I had to rely upon the statement of others. If before the survey I had studied the behavior of the river at this point at the various stages, which would require fully

a year to do, my estimate would have contemplated the Suck as a difficulty both at low water and moderate high water, the most lasting stage of the river.

I feel that I cannot exaggerate the importance of making the improvement of the Suck an accomplished fact. I regard the success of the whole Tennessee River improvement as dependent upon the result of the work commenced at this point. The eyes of the people have for months been directed to it by the press, until it has become the focus of intense interest.

If the obstructions of the Suck are conquered, the whole enterprise will gain a prestige with the people most interested that will insure the completion of the entire work from Chattanooga to Paducah.

If the work at the Suck is permitted to fail of accomplishing the desired object, I fear the subject of the improvement of the Tennessee River will fall into obscurity, if not into oblivion.

It is my opinion now, that owing to the impossibility of obtaining adequate information as to the character of the Suck at ordinary high water during the survey of last year, the estimated enlargement of the water-way may be inadequate, and it occurs to me that rather than have the work fail at this important point it would, if necessary, be judicious to concentrate the entire appropriation here. But I do not think this will be necessary.

The contract for the Suck has been so modified as to permit the excavation to be made upon the boulder bar almost entirely. I would recommend the excavation of the boulder bar to the amount of at least 17,877 cubic yards, and of the middle wall 1,250 cubic yards. That is based upon the supposition that you understood Mr. Dennis to be entitled to one dollar per yard for dredging at the bar. If held to his contract, at seventy-five cents, I should recommend the excavation of 23,836 cubic yards, as it is impossible to remove too much of the bar.

At the Pot, instead of 5,000 cubic yards, rock excavation, I would for similar reasons recommend an increase to 9,400 cubic yards.

The price of the additional work at these two points is equal to the amount heretofore directed to be applied to Ross's Tow Head, Burroughs's Bar, and Kelley's Shoals.

I am satisfied, from my observations of popular opinion, that the one thing needful to inspire the people here with confidence in themselves, and in the development of their country, is the successful improvement of the Suck, and this conviction has induced me to treat the subject at detail, with the hope that you may appreciate its importance to the people whom it was intended to benefit.

All of which is respectfully submitted.

WM. B. GAW,
Superintendent Tennessee River Improvement.

Bvt. Maj. Gen. G. WEITZEL,
Major United States Engineers, Louisville, Kentucky.

APPENDIX M.

Annual Report of Colonel J. N. Macomb.

OFFICE OF WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, August 27, 1869.

GENERAL: In obedience to the requirements of the circular from your office, dated 12th June, 1869, I beg leave to lay before you the follow-

ing annual report upon the works under my charge as superintending engineer of the "improvements of the western rivers, except the Ohio River," for the year ending June 30, 1869.

As has been heretofore stated, the extent of the work required for improving these rivers is so great, and, I may say, the field is so vast, and the nature of the work of such a character, as to bring these improvements under the class of indefinite, or "admitting of no permanent completion," still the measure of success which has attended our labors has been such as to encourage a continuance of them, and to justify the asking for increased aid to push forward the work in accordance with the extent and importance of the interests involved, immediately affecting the commerce of the great valley of the Mississippi, in its most enlarged acceptation.

The operations have been conducted under the following heads:

I. Construction of snag-boats, and machiney, &c.

II. Examination and survey, &c., of western and northwestern rivers.

III. Improvement of the Mississippi, Missouri, and Askansas Rivers.

I.—CONSTRUCTION OF SNAG-BOATS, AND MACHINERY, ETC.

At the commencement of the fiscal year, on 1st July, 1868, we had three double-hulled snag-boats that had been a short time in service, and that had given promise of the good work that this year's record will show for them. They are the J. J. Abert, the S. H. Long, and the R. E. De Russy. (See papers A, B, and C.)

In the course of the year but one snag-boat, the S. Thayer, and one dredging-boat, the Octavia, have been added to our fleet. The snag-boat is of light draught, and was built for use in the Arkansas River. The dredging-boat is a favorably known Missouri River steamboat, that was purchased after having shown herself, in a few weeks' trial, to be well adapted for this service.

II.—EXAMINATIONS AND SURVEYS, ETC.

During the summer of 1868 a small party was kept at work on the snag-boat De Russy, making a partial survey of the lower part of the Missouri River. During the winter of 1868 and 1869, a careful reconnoissance was made of the Mississippi River, and a map of the same constructed for the use and guidance of our operations, embracing, with but few breaks, the river from Alton, Illinois, to Grand Gulf, Mississippi. During the present season a similar reconnoissance has been pushed up the Missouri River, which has been mapped from the mouth to Yankton, Dakota.

A large and complete surveying party was organized for the survey of the Arkansas River. They left Cincinnati, Ohio, January 15, and reached Fort Gibson, Indian Territory, February 7. The survey was begun at Fort Gibson, and continued to Little Rock, a distance of two hundred and ninety-nine and a half miles. This party was in charge of Mr. S. T. Abert, my assistant, whose preliminary report is herewith appended. (Paper H.)

III.—IMPROVEMENTS OF THE MISSISSIPPI, MISSOURI AND ARKANSAS RIVERS.

The improvements have been confined chiefly to the pulling and destroying of snags, cutting timber to prevent the formation of snags, and

dredging bars. An account in detail, of the operations of our fleet of five boats, is submitted herewith, and attention is respectfully asked to the accompanying tabular statements showing the number of snags destroyed, with particular information relating to each snag.

At the commencement of the fiscal year in July, 1868, the United States snag-boat J. J. Abert was at work in the Mississippi River, between Cairo and Memphis, and so continued until compelled by the sickness of her crew to come to Cairo to refit. In September she resumed work on the Mississippi between Cairo and St. Louis, and continued in that part of the river until the 21st of November, having, in the course of her cruise, worked up to within about forty miles of St. Louis.

Her next cruise was in that part of the river between Cairo and Memphis, which she succeeded in clearing out pretty well for the time, and she was then ordered down to Vicksburg, to work thence down the river as far as snags might be found troublesome. Under these orders she reached Bayou Sara, Louisiana, on the 5th of January, 1869, and turned about, working back to Vicksburg by the end of the month, when she was returned to her former field, between Memphis and Cairo. In the month of February her services were very important in clearing the chute about fourteen miles above Memphis, called the Outlets. She continued in that district until 9th of March, 1869, when one of the engines of the hoisting apparatus broke down in pulling a snag, rendering it necessary to return to port for repairs, which kept her from the field the rest of the month. For a part of April she worked in the Mississippi, below St. Louis, and towards the end of May had reached a point on the Lower Missouri River, about seventy-one miles above St. Louis, where she had the misfortune to run upon a sunken log which stove in her bottom, disconnected her steam-pipes, and displaced and broke her steam bilge pumps, and caused her to leak badly. By this accident the boat lost a week's time from her work, and but for the promptness of the dock company at Carondelet, she would have been delayed much longer. She was actively engaged during the month of June in her summer beat—the lower district of the Missouri River.

The S. H. Long, in July, 1868, moved up from the mouth of the Arkansas to Mound City, Illinois, to refit, in consequence of sickness contracted down the river. She was detained at Mound City for repairs during the month of August, and in September was actively employed in the Mississippi, above Cairo, and in the mouth of the Missouri. In October she was ordered to the Mississippi again, below Memphis, and continued working between there and Ozark Island during the months of November and December, returning to Memphis on 4th January, 1869, when she started down the river to go over her beat again, clearing out Burdeau and other obstructed chutes on the way. She was one hunded and twenty miles below Memphis at the end of January. She continued in the district between Memphis and Ozark Island, and reached Helena, Arkansas, on the 1st of March, and came to Mound City, Illinois, for repairs, just after the middle of March. On the 2d of that month a sad accident occurred, by which we lost one of our laborers, who was swept overboard from the Long by the breaking of a snag, the falling portion of which struck the man and rendered him powerless. Efforts to save him proved fruitless, as he was swept under the boat by the strong current of the Mississippi, and he could not be found.

After completing her repairs, the Long proceeded to the Missouri River towards the end of April, having been assigned to the middle district of that river, where she was still at work at the close of the fiscal year.

As stated in the last annual report, the De Russy had, at the end of June, 1868, reached the vicinity of Hermann, in the Missouri River. From that point she continued to work up the river until about the 1st of October, when she had passed a short distance above Brunswick, or some three hundred miles above St. Louis, when it was found necessary to turn about from the low stage of water and the advancing season. The descent of the river was attended with considerable delay, and some danger to the boat. A sunken log was struck on the way, which broke some fourteen of the floor timbers, but led to no serious leaking. She came out of the Missouri River towards the end of October, and at once commenced work in the Mississippi, chiefly between St. Louis and Alton, and continued in that part of the field until about the 10th of November, when she went to Mound City for repairs. After which she worked down the Mississippi River, reaching Vicksburg on 27th December, 1868, when she turned about to go over her field again, and was, at the end of January, about ninety miles above Vicksburg. During February the De Russy worked between Ozark Island and Vicksburg, and in March she worked her way up the river, destroying such snags as were accessible. In April she was undergoing repairs and outfitting for the summer's operations, having been assigned to the uppermost of the three districts of the Missouri River, in which field she was still at work at the close of the fiscal year, 30th June, 1869.

The first scheme for the summer's operations of these three boats in the Missouri River was to place them in districts, as follows: snag-boat Abert, lower district, from the mouth to Lexington, Missouri; snag-boat Long, middle district, from Lexington to Nebraska City, Nebraska; snag-boat De Russy, upper district, from Nebraska City to Sioux City.

The De Russy, however, encountered such shoal water and narrow channels, above Omaha, that it was found to be expedient to bring her below Omaha, and to modify the limits of the districts so as to equalize the work on the Missouri River among the three snag-boats.

The light-draught snag-boat S. Thayer, which was launched in February, left Cincinnati at the end of April, and went to the Arkansas River. She reached Little Rock on the 14th of May, and proceeded to Fort Smith, and began the arduous labor of clearing the snags from that river, and is still at work there.

The dredge-boat Octavia was chartered November 7, 1868, and fitted with Long's scraper. November 22 to December 3, cruising in the Mississippi between Cairo and Alton. Boat purchased for the United States December 3, 1868. From December 7 to 16, cruising in lower Mississippi. From December 16 to January 5, 1869, lay at Mound City, Illinois. January 5, 1869, ordered to Cincinnati, Ohio. January 15, left Cincinnati, and towed survey-boat Arkansas, with surveying party on board, to mouth of Arkansas River. Returned to Cincinnati February 6th. From February 6 to March 27, lay at Cincinnati, making alterations and repairs. From March 31 to May 2, lay at Mound City. Entered Missouri River May 4, and has worked there, dredging the bars with good success, to the close of the year. Without the aid of this steamer to dredge bars and tow against some of the stiff currents, it would have been impossible for the snag-boats to have navigated so far up the Missouri as by her aid they succeeded in doing. See letter from my assistant, Major Suter.(Paper G.)

While these boats have all done remarkably well, surpassing, indeed, the expectations in regard to them, they have demonstrated the necessity of having more boats, and particularly some of a lighter draught of water.

There is a practical difficulty in combining the great strength, which it is desirable that a snag-boat should possess, with that lightness of draught which is requisite for working at the lowest stages of water, when the most dangerous snags become visible. I believe, however, that we are now in possession of plans that, with the experience which has been gained in the last eighteen months, will enable us to produce the right sort of boat, in case further appropriations should be granted for continuing these western river improvements, which have been so well begun.

Since these boats began to operate, changes have been made in points of minor detail, which have greatly simplified and expedited the process of destroying snags, and at the same time demonstrated, I think, the feasibility of making a lighter-draught boat that will do the work effectually.

To show what is thought of the boats and machinery of our fleet, by engineers of much longer experience on these western rivers than I enjoyed, I beg leave to refer to the special report of Major H. C. Long, United States civil engineer, dated January 20, 1869, and that of Mr. W. Milnor Roberts, United States civil engineer, dated May 13, 1869, copies of both of which reports are herewith submitted, E and F.

With such evidence in favor of my operations, I feel that we may confidently expect that appropriations will be granted to provide for continuing these works on a scale adequate to their importance, as set forth in my annual estimates, which I have laid before you to accompany this report.

The following is a recapitulation of the work done by the several snag-boats during the fiscal year:

Names of snag-boats.	Number of snags pulled and destroyed.	Weight of snags in tons of 2,000 pounds.	Number of trees cut down.	Roots cut off trees under the bank.	Drift piles removed.
J. J. Abert, (A)	952	12, 865 14-100	4, 648	145	7
S. H. Long, (B)	767	13, 006 5-10	3, 789	443	25
R. E. De Russy, (C)	928	9, 161 6-100	4, 727	None.	4
S. Thayer, (D)	50	726 2-10	1	None.	None.
Grand total	2, 697	35, 758 9-10	13, 165	579	36

It may be observed, that in reckoning the weight of snags, it was only during the last four months of the fiscal year that the weight of roots was taken into the account. If this had been done from the first, the number of tons would probably have been some 70,000, instead of the 35,758.9, as shown in this table; for it is found that the root, with the earth which it generally brings up with it, much exceeds the rest of the snag in weight.

OPERATIONS FOR PRESENT WORKING SEASON.

It is expected to continue the operations, as now carried on, during the remainder of the present working season, taking the snag-boats and dredge-boat to other parts of the field, as the stage of water and the necessities of the navigation may demand. The dredge-boat will probably be at work upon the bars of the Mississippi, between Keokuk and St. Louis, and perhaps between St. Louis and Cairo, as may be needed.

It is supposed that the demand for her services will probably be greater than she can respond to. In the course of September it is expected that all of the boats will be drawn from the Missouri and employed upon the Mississippi, and as soon as the fall rise may give sufficient water in the Ohio, one of our snag-boats will probably commence to work up that river, from the mouth.

The surveys will be limited to such as may be required preparatory to dredging the bars, and will be executed by the assistants now on board of the dredging-boat.

The Arkansas River surveying party having been reduced to the force necessary for carrying on the office work, will be continued at that until the completion of the maps requisite for exhibiting the results of the survey.

The light-draught snag-boat, S. Thayer, it is expected to continue at work in the Arkansas River. As soon as the cold weather sets in it is expected to send the fleet, now working in the Missouri, to work in the mouth of the Arkansas River, and as far up that stream as the stage of water may then admit of their working. They will also find work in the lower Mississippi, and will be kept at work as long as the funds in hand will justify it. It will probably become necessary to lay them up by the month of March, 1870, unless additional funds for keeping them at their useful and acceptable work shall be granted before that time.

I have introduced this subject into my annual estimates under the head of "Improving the Mississippi, Missouri and Arkansas Rivers," and have asked that the sum of eighty thousand dollars may be appropriated at as early a day as possible to enable us to prosecute these labors uninterruptedly to the end of the current fiscal year. Indeed, the delay incidental to laying up the boats of our working fleet would be a most serious loss, as it would throw the boats out of service just at the time when the work can be most advantageously pushed forward in the Missouri River, the most difficult part of the field. I trust, therefore, that the sum above named may be appropriated in advance of any general appropriation.

Besides the annual estimate, which has already been forwarded, the following papers are referred to in this report, and are forwarded with it:

Snag-list of the J. J. Abert, for the year ending 30th June, 1869, marked A.

Snag-list of the S. H. Long, for the year ending 30th June, 1869, marked B.

Snag-list of the R. E. De Russy, for the year ending 30th June, 1869, marked C.

Snag-list of the S. Thayer, for the year ending 30th June, 1869, marked D.

Report of United States Civil Engineer H. C. Long, marked E.

Report of United States Civil Engineer W. Milnor Roberts, marked F.

Report of my assistant, Major C. R. Suter, captain engineers, marked G.

Report of my assistant, Mr. S. T. Abert, marked H.

Paper showing amount disbursed on these works in last fiscal year, marked K.

All of which is respectfully submitted by your most obedient servant,

J. N. MACOMB,
Colonel Engineers, Brevet Colonel United States Army,
General Superintendent United States Snag-boats, and
Western River Improvements.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers U. S. A.,
Office of Chief of Engineers, Washington, D. C.

N.—*Abstract of contracts made on account of the construction of snag-boats and apparatus for clearing western rivers.*

Name and residence of contractor.	Date of contract.	Designation.	Amount.
Niles Works, Cincinnati, Ohio	October 28, 1868.	Light-draught snag and tow-boat.	$27,500 00

M.—*Abstract of proposals for the construction of a light-draught, double-hulled snag-boat and tow-boat, complete, designed for the Arkansas River.*

No.	Name and residence of bidder.	Amount.
1	C. T. Dumont, Cincinnati, Ohio	$32,500 00
2	William Jones, New Albany, Ind	31,000 00
3	James Howard & Co., Jeffersonville, Ind	27,982 00
4	J. N. Snowden, Brownsville, Pa	27,000 00
5	Niles Works, Cincinnati, Ohio	27,500 00

E.

NEW YORK, *January* 20, 1869.

GENERAL: I forward herewith a report of H. C. Long, United States civil engineer, on his examination of the boats operating under direction of Colonel J. N. Macomb. I received it January 9, but supposed it was sent me for my information only, as Major Long had been directed to report to Colonel Macomb, and I supposed had made full report to him. On seeing Colonel Macomb in Washington, on the 16th instant, he informed me that no report had been made to him, he having suggested Major Long to make it to me. The irregularity of the proceeding accounts for my having kept it so long. I now transmit it to you as an inspection report made by Major Long, and which, as such, I think, should have been addressed directly to the bureau.

He speaks in terms of high commendation of the new snag-boats built by Colonel Macomb.

Yours, respectfully,

G. K. WARREN,
Major Engineers, &c.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brigadier General and Chief of Engineers U. S. A.

UNITED STATES ENGINEER OFFICE,
Saint Paul, Minnesota, January 1, 1869.

GENERAL: In accordance with the suggestion of Colonel John N. Macomb, Corps of Engineers, general superintendent United States snag-boats and western river improvements, dated at Cincinnati, November 10, 1868, that "I should be ordered to report to him for the purpose of a mutual comparison and interchange of opinions and suggestions upon the several subjects of dredging with Long's scraper, and of destroying snags with our improved snag-boats," and approval of the same by the Chief of Engineers and myself, I left Saint Paul for the purpose specified on the 18th of November last.

On the 27th November I received a telegram at Alton, Illinois, from Brevet Major Charles R. Suter, Corps of Engineers, as follows:

ST. LOUIS, *November* 27, 1868.

To Major H. C. LONG:

Will be at Alton this p. m. on steamer Octavia.

Major Suter arrived at Alton with the Octavia at the appointed time. The next day was devoted to an examination of the Long's scraper, attached to her bows, and a trial of the same on the bar about three-fourths of a mile above the city landing. This bar crosses the river obliquely from the Illinois shore, trending down the river till it nearly reached the dry sand-bar on the Missouri side, and was slightly overlapped by a short bar extending from the latter, forming quite a serious obstruction to the passage of heavily-loaded steamboats. The best water across same was found to have a depth of four and a half feet. At this point the experiments were made with the Octavia scraper. Six successive drags or scrapes were made across the obstruction, occupying about two hours from the time we left the Alton landing till we returned. In that time the depth of water on the bar was increased to six and a half feet, and I have since been informed by pilots, and other river men, that we so cut up and loosened the bottom of the river, that in the course of three or four days afterwards the current washed out a channel ten feet in depth, in the direction and along the trace scooped out by the scraper.

We find that the greater width of the river gives better facilities for maneuvering the scraper than met with above the rapids, and tends to the conviction that the machine will work equally as well in the Lower as in the Upper Mississippi, the frame-work which carries the cutters or buckets, the slides and drag-chains, being proportionately lengthened.

The Octavia, at the time of her visit to Alton, was under charter by government for a limited period; it had not been concluded to purchase her; on this account the scraper was not mounted with a view to permanency, and the lowering and raising of the machine on to and from the bars was accompanied by considerable delay and difficulty. The scraper had but four cutters instead of five, as used in the upper river on those of largest size. Accordingly, it was recommended that certain improvements be made in the apparatus for handling the machine, and that a larger scraper be attached to her bows; after which it is confidently expected that, with proper management, the Octavia will do most efficient service in dredging the bars between Keokuk and Cairo. She is a powerful, well-built steamboat, light draught, commodious, and in all respects admirably well suited for the service intended.

On the 5th of December I joined Major Suter at Cairo. The next day we went to Mound City and inspected the large, double-hulled snag-boat De Russy. On the 7th we started from Cairo, with the Octavia, for the Lower Mississippi, for the purpose of observing the operations of the other large twin snag-boats J. J. Abert and S. H. Long. We met the former at Fletcher's Landing, on the evening of the 8th of December, and remained with her that night and till eight o'clock next morning, during which time we went on board and examined thoroughly all the details of her machinery, and witnessed her operations in extracting a dangerous snag from the main channel of the river. This snag was a cottonwood tree ninety feet long, three feet two inches in diameter at butt, tapering to a few inches at the top. The boat was about fifteen minutes raising it from the water and placing it on the rollers be-

tween the two hulls, preparatory to its being cut up and otherwise disposed of. This was not considered by any means a fair test of the capacity of the boat, as the snag was not firmly imbedded in the mud at its roots, and was under the average size of snags in this locality. But it served to show the method of maneuvering the boat, handling the machinery, the discipline of the officers and crew, &c., and in these particulars was very satisfactory. On the afternoon of the same day (December 9) we arrived at Memphis, Tennessee, and lay there till 10.30 next day, taking on coal, stores, &c. From this place I reported to you.

On the morning of the 11th December we overtook the snag-boat S. H. Long, in Friar's Bend, ten miles below Helena, Arkansas. After inspecting her we turned up the river again, arriving at Memphis on the 12th, meeting and visiting the De Russy on her way down, a few miles above that city. We also made a second visit to the J. J. Abert on the 13th December, near Island 37. At that time she had a snag on her rollers—cottonwood tree—measuring, exclusive of very heavy and wide-spreading roots, one hundred and thirty feet in length, sixteen feet in circumference at the large end, and eight feet in circumference at the small end. The captain of the boat informed me that it took them three and a half hours to get this snag on to the boat, and that it would take about as much longer to cut it up and put it out of the way, or about seven hours' work in all to dispose of a snag of these dimensions.

In the meanwhile it had turned very cold, the mercury having been as low as +15° at Helena, the morning we were there. We encountered heavy floating ice about two hundred miles below Cairo, and with considerable difficulty reached that city on the evening of December 15.

The next day Major Suter and myself went on the cars to Cincinnati; the Octavia having been sent to Mound City to have the alterations made in the mounting of her scraper, suggested in the former part of this report, and to undergo other slight alterations, the boat having been purchased by government.

On the 17th December we reported to Colonel Macomb, at Cincinnati, and accompanied him and Captain Shields, head machinist, &c., in an inspection of a light-draught machine-boat and small stern-wheel boat for the propulsion of same, building and on the ways in the upper portion of that city. We also visited the foundery and examined castings and machinery in preparation for same boats.

Having thus completed the duties assigned me as per instructions, &c., mentioned in the early part of this report, I returned to St. Louis, &c., &c., and reported to you accordingly.

I take this occasion to express the gratification afforded by the inspection and operations of the large twin snag-boats, J. J. Abert, S. H. Long, and R. E. De Russy. These boats appear to be most substantially built of the best material, and complete in all their appointments, well officered and well disciplined, They are, in many respects, great improvements on the old snag-boats, such as built by Captain H. M. Shreve, Captain John W. Russell, and others, in that the old boats had but one set of engines; these not only propelled the boat, but worked the snagging gearing when disconnected from the paddle-wheels; whereas in the boats built under the direction of Colonel Macomb, the propelling power is distinct from that which works the snagging apparatus; and various other time and labor saving contrivances are introduced, such as steam gearing for sawing up the snags, steam capstans, steam hoist for the drag chains, &c., &c., while, as before said, the old snag-boats had but one pair of engines with which to perform all the work required of them, and drive them from point to point, long dis-

tances on the Mississippi, Missouri, Ohio and Arkansas Rivers, involving journeys many thousand miles in the aggregate. If I recollect rightly, the new snag-boats have six pair of engines. This fact must be taken into consideration in estimating the comparative efficiency and amount of work performed by the two classes of boats, the old and the new.

In respect to accommodations for officers and crew, the new boats are so superior to the old that no just comparison can be instituted between the two.

In conclusion, I beg leave to say that, from opportunities afforded of conversation with river men, I am of the opinion that there is but one expression in regard to the operation of the snag-boats, and that is of universal commendation. They have already accomplished a great deal, but much more remains to be done.

Very respectfully, your obedient servant,

HENRY C. LONG,
United States Civil Engineer.

Brevet Major General G. K. WARREN,
Major Corps of Engineers,
Sup't Northwestern River Surveys and Improvements,
St. Paul, Minn.

F.

PITTSBURG, *May* 13, 1869.

GENERAL: Being recently in St. Louis, at the time when Colonel Macomb happened to be there with the United States snag-boat J. J. Abert, he kindly invited me to accompany him up the Mississippi, in order that I might witness her working.

I had for some time desired to see for myself how that class of boats operated, and was very glad to embrace this excellent opportunity.

The Abert started from St. Louis shortly before noon of Friday, the 7th of May, and made excellent progress—from five to six miles an hour—against a current of nearly five miles an hour. Three miles up, just below the new city water-works, we met the first snag, which was pulled and on board in just six minutes from the time the Abert stopped her headway. The steamer was then immediately put under way, moving slowly up stream, searching for another snag, and at the same time sawing up with steam saws the one on board. This was a sycamore, fifty feet long and thirteen and a half feet in circumference at the butt. The total time, from the beginning, when we were entirely clear of the tree, was twenty minutes. Within ten miles of the city, two more snags were met, pulled on board and cut up—one being forty feet long and eleven feet in circumference. The first was brought on board in six minutes, and the other in eight minutes from the time of stopping headway. About fifteen miles up she took a fourth large snag, ninety feet long and fourteen feet in circumference. This proved to be more difficult, on account of the limbs, though it was on board so as to apply one saw in five minutes, and the boat put under slow motion. We were entirely clear of it in one hour and thirty-six minutes, during which time, however, we ran several miles up. Just above the mouth of the Missouri River, she took another large troublesome tree, which had large limbs buried in the sand, and the root partly afloat, and which had to be pulled out root foremost, but seemed to make little difference. This was seventy-five feet long and twelve feet in circumference. It was on board

and the boat under slow way in eight minutes. This was at seven o'clock, or about seven hours after leaving Saint Louis. Thus she pulled five snags between noon and seven p. m., and made twenty miles on the river. We then ran over to Alton for the night, twenty-four miles from Saint Louis, arriving after eight o'clock.

I carefully watched the working of the Abert, and the use of her gearing, chains, and saws, and the management, and the conclusion in my mind is that the whole arrangement is almost perfect for the purpose of rapidly taking up and disposing of large snags, even the very largest.

I only say "almost" perfect, because slight improvements doubtless may be made in the building of another boat.

The improvement recently introduced, carrying the steam saws forward, and placing one of the side saws *near the bow*, so as to cut off the stump at once when desired, with the other steam saw making another cut at the same time, seems to me admirable. It certainly worked beautifully on the occasion I refer to. The motion of the gearing might be made in future boats rather slower, but as a whole, as a snag machine, just as she is, the Abert is very far superior to anything I ever saw in operation anywhere. I am entirely satisfied that this boat, or a similar snag-boat, is precisely what is needed for the purpose of removing snags from the Mississippi, Missouri, Arkansas, and other snaggy rivers, and that it would be well if one of these boats could be detailed to work up the Ohio River as far as Louisville, and, if she should get by the falls, to work up to Cincinnati, or as far as she could go. I believe that a light-draught steamer, built on the same general arrangement, would remove snags to a great advantage on the upper Ohio, if snags were abundant, or if they were the chief obstruction on that part of the river.

But on the upper Ohio more time is required for the removal of wrecks of coal boats, barges, steamers, &c., which require for each case special management, sometimes partial dredging of coal, gravel, &c., and lifting, and occasionally blowing up.

I have no doubt that if the government had adopted, or should have occasion to adopt, a *permanent system* for removing obstructions from the Ohio River, that a light-draught steamer could be arranged on a somewhat similar plan, so as to do work advantageously. But in the absence of any permanent system at present, and without yet knowing to what extent the removal of obstructions annually may be required in the future, our method of working by contract with, say, two light-draught steamers, is, I think, the best for this season between Pittsburg and Cincinnati; and below Cincinnati, as far as Louisville, in case one of the government snag-boats referred to can be spared this season, and can get above the falls, it would probably be economy to let her work up as far as she could go. Meanwhile two contract steamers, as indicated in my letter dated April 5, 1869, could be employed to advantage working down stream at different points from the head of the Ohio.

The government snag-boats being on hand, I have now no doubt that one of them could work at removing snags between Cairo and Louisville to better advantage than with our contract system. I therefore respectfully recommend that Colonel Macomb be authorized to use one or more of them, whenever he can conveniently place them, on the Ohio River below where any contract steamer may be working.

Very respectfully, your obedient servant,

W. MILNOR ROBERTS,

U. S. Civil Engineer, in charge Ohio River Improvements.

Major General A. A. HUMPHREYS,

Chief of Engineers, U. S. A.,

Headquarters Corps of Engineers, Washington, D. C.

G.

UNITED STATES STEAMER OCTAVIA,
St. Louis, Mo., June 29, 1869.

COLONEL: We arrived at this place early this morning, having since we left here pushed nearly a thousand miles up the Missouri River. As I informed you in my hurried note from Cairo, the river fell very low after the early spring rise, and for some time was nearly impassable. I kept in company with the snag-boats as far as Lisbon, and then pushed ahead to clear the way for them. The lower river had cut out very fairly, but the upper portion was still reported in very bad condition. We did some dredging at a place called Eureka, with good success. Above Leavenworth the river began to shoal fast, and at Smith's Bar, twenty-five miles below St. Joe, we were unable to cross, ourselves. After some delay by wind, we cleaned this bar out successfully, and it has since remained in very good shape. Twenty miles above here we dredged again at the head of Hell's Half Acre. This place has also held out well. After this we kept on up to Omaha, examining the river carefully and dredging wherever necessary. We turned back from Omaha, and kept on down the river to Smith's Bar, meeting the De Russy and Long, on the way. Finding the river at a good stage, I turned back to see about getting the De Russy above Omaha. Found her below Omaha unable to stem the current. We helped her up stream, however, and the river beginning to fall, she came on all right. We kept up the river about eighty miles. I found the river getting very small and shoal, and falling fast. The De Russy looked in it like a whale in a mill-pond. There were very many snags, but she could only pull those directly in her road. I could have taken her up to Sioux City and back, by digging and hauling her over the bars, but I thought the game would hardly pay. The snags were all bedded very deep, and would not stand a pull, but broke off short in the sand. Finally I gave Captain Birch orders to drop below Omaha. The river was falling fast and we just got the De Russy out, and no more. Below Omaha the river is deeper than above, owing probably to the frequent passage of boats, and also to the considerable accession of water from the Big Platte. Below there I do not anticipate any very serious trouble, till toward the close of the season. Leaving the De Russy at Omaha, I kept on down the river, examining everything very carefully. Dredged at Sonora, Hell's Half Acre, and Weston. Below this last point no work was found necessary. On the way down, I visited the Long and Abert, and had a good opportunity of judging of the amount of work done by them. The snag-boats are all working with great zeal and efficiency. They have already done an immense deal of good. I propose to keep them at work in the Missouri as long as I can safely, gradually working them down the river as the water falls. When they get tolerably near the mouth, I shall feel confident of being able to extricate them with the scraper. This latter machine works far better in the Missouri than I dared to hope for, but the one on board the Octavia is too small for any but a very small river. After careful consideration and planning, I have decided on building one with six buckets, and ten feet additional length. All the iron work of the present scraper can be used on it, and it will soon be finished. The same machinery will handle the new scraper as did the old one. The expense of the new scraper will be trifling. This work will probably take me about a week, after which I shall be ready for any new work. The rivers are all swelling at present. I have heard from Mr. Abert,

who informs me that the present rise is likely to put an end to his hydrographical work.

* * * * * * * *

I am, colonel, very respectfully, your obedient servant,

CHAS. R. SUTER,
Brevet Major United States Army, Captain Engineers,
Assistant in charge Field Operations, United States Snag-boats, &c.

Colonel J. N. MACOMB,
Engineer, Sup't Western River Improvements.

H.

CINCINNATI, OHIO, *August* 28, 1869.

COLONEL: I have the honor to submit the following preliminary report of the survey of the Arkansas River, from Fort Gibson to Little Rock, a distance of two hundred and ninety-nine and a half miles.

After receiving your instructions as to the objects and method of the survey, the party was organized with the following named officers:

Ernst Rühl, R. E. McMath, H. A. Pattison, J. D. McKown, assistants; H. G. Webber, draughtsman; C. A. Good, clerk.

One mate and thirty-four men were employed, in the various capacities of chainmen, sounders, axemen, deck-hands.

The portion of the river surveyed has its course partly in the Indian Territory, and partly in the sparsely settled counties of the State of Arkansas. It was represented to be subject to freshets, and during the intervening stages to be much obstructed by snags. To transport securely and expeditiously the party employed, it was necessary that a substantial boat should be built for the special purpose.

The approach of winter delayed the completion of the survey boat. It was not until January 15 that the party embarked, in tow of the United States steamer Octavia.

Leaving the mouth of the Arkansas River, January 24, in tow of a river packet, the party reached Fort Gibson February 7, being detained by high water and head winds.

The day after reaching Fort Gibson the symptoms of small-pox were manifest, and the survey was temporarily deprived of the services of three officers and two men. For a time the success of the expedition seemed doubtful.

The sick were immediately placed in camp, and the survey commenced the same day was continued, with several short interruptions from high water, to its completion at Little Rock on June 30.

Here operations were suspended, according to your instructions.

The method of survey was as follows:

The course of the river and topography was noted by two parties, one on each bank.

The line upon the left bank was surveyed with the solar compass; the true meridian being determined at every station when the sun was visible, and all the lines of the survey were referred to it as the standard. The latitude was also approximately determined by this instrument, and occasionally checked by observations with a Würdemann sextant.

The right bank was surveyed with a transit, (Würdemann,) all angles being referred to the standard meridian, as determined by the solar compass. The correctness of this standard was further verified by

observations upon the elongation of Polaris. The two lines above described were connected every mile by triangulation.

The same parties also established hydrographic stations, consisting of flags, lettered alphabetically, which served as terminal points for the lines of soundings. The points were occasionally fixed by the hydrographers.

The hydrographic party sounded the river from bank to bank. Shoals, reefs, and the edge of bars were carefully determined by soundings fixed by triangulation, but as far as the channel remained unobstructed, the soundings were taken by cadence, or at fixed intervals of time.

Sub-surface velocities were taken, and also all observations requisite for determining the discharge of the river at intervals of ten to twenty miles, according to the suitability of the locality for this purpose.

The floats employed in these measurements were composed of pieces of tin, placed at right angles, so as to present four vanes to the action of the water, and were secured by cords to corks bearing small red flags. The cords were lengthened, so as to bring the vanes to mid-depth, whenever velocities for ascertaining the discharge were measured.

The vanes were launched from a boat at distances sufficiently near to give the mean velocity at many points along the line of the cross-section, and their transit was observed from two theodolites at the extremity of a base of one hundred feet in length. This length of base left no space for eddies or changes in the current, and always gave favorable results. The measurements were usually taken when the river averaged eight hundred and fifty to one thousand feet in width.

These observations were conducted in the manner described in the delta report of Generals Humphreys and Abbot.

The leveling party were directed to touch upon the surface of the water every half mile, and to assist in the establishment of gauge-rods, and to carry lines of levels across the valley, from bluff to bluff, at all points where measurements for discharge were taken. Gauge-rods were established at intervals of from twenty-five to thirty-miles, and observers were employed to keep a record of the stage of the water every morning and evening.

Similar observations were kept up hourly at the boat, during the day and night.

These observations, besides illustrating some of the phenomena of the river, are useful in eliminating the oscillation, and also to enable the hydrographer to reduce his sounding to a co-instantaneous plane of the water surface.

The plane of reduction of all the sounding was assumed at three feet above low water, being the lowest stage observed during the survey, and exhibits the river anterior to the condition when it begins to cut through the shoals.

Permanent marks were left at stated intervals along the line of survey by all the parties.

During the period of the survey the oscillation of the river ranged from three feet above low water to twenty feet, and reached twenty-six feet about 6th July, just after the conclusion of the survey.

The low water was accurately determined at several points by the testimony of competent observers, but these points were so distant that it became requisite to assume that this plane varied in inclination in conformity with the slope of the surface as determined by each day's observation with the level. A succession of inclined planes was thus obtained, agreeing, as near as possible, with the co-instantaneous plane of the low-water surface.

It is proposed to continue the observations upon the gauge-rods until the lowest water is ascertained.

Information supplied by these observations is also useful in determining the average stage of the river upon any day when any one of the gauges is observed.

The distance from Fort Gibson to Fort Smith is 95½ miles, and from Fort Smith to Little Rock the distance is 194 miles—the entire distance being 299½ miles. These distances were largely overestimated by steamboat men.

The difference of level, when the water is at a stand, between Fort Gibson and Fort Smith is 104 feet; between Fort Smith and Little Rock it is 160 feet; the total difference between Fort Gibson and Little Rock being 264 feet. The fall per mile varies from $\frac{2}{10}$ of a foot to one foot and $\frac{30}{100}$.

The width of the river between banks varies for different stages of the water from the dimensions of a small creek to that of a majestic river 1,500 to 2,000 feet wide.

Snags are numerous, and become very dangerous when the river falls to four feet above low water.

The low-water season occurs in November, and other low-water periods at irregular intervals during the summer and fall, the river responding to the meteorological vicissitudes of the extensive area drained by its tributaries.

The average condition of the river from the day the surveying party entered it (January 24th) until it again re-entered the Mississippi (July 3d) was very favorable to navigation.

During the low-water stage the shoals and bars are considerably modified by the concentrated action of the water, which cuts out the sand to a depth of two or more feet. The survey having been made during the continuance of high water, it is impracticable to represent the condition of the river at the interesting period of low water.

The following table represents the height of the river above low water during the months named:

Months.	From Fort Gibson to Fort Smith.	From Fort Smith to Little Rock.
1869.	*Feet.*	*Feet.*
January	20.0 to 0.0	20.0 to 0.0
February	13.0 to 7.1	12.0 to 6.5
March	19.9 to 3.4	11.9 to 3.4
April	13.7 to 6.5	13.8 to 5.5
May	15.4 to 5.2	11.6 to 3.8
June	21.0 to 8.1	19.4 to 6.6
July	28.0 to 8.0	26.0 to 3.9

This favorable condition appears to have prevailed during the winter for several successive years, yet the general opinion that this prevalence of high water was unusual at these periods deserves consideration.

The most noted flood, known as the "June rise," comes from the Upper Arkansas, and is remarkable for its red color.

Ordinary high waters range from eighteen to twenty-five feet, but extraordinary floods average, throughout the entire year, from twenty-seven to thirty-five feet. At twenty-six feet the floods cause considerable damage to the crops.

Although not strictly separable into two terraces, the valley of the Arkansas may be generally described in that way. The upper terrace contains the larger and most productive part of the river bottom. The

lower is frequently overflowed, but the higher terrace has not been covered since 1844.

The winter of 1868 and '69 was a period of general high water upon all the western rivers.

Had the floods, which occurred in succession, happened more closely together, we should have had to record a year of extraordinary devastation to the crops.

When the survey closed at Little Rock, according to your instructions, the river was still rising and reached the height of twenty-six feet on 8th July.

Here bench-marks were established and the lines of the transit and solar compass parties were fixed by permanent marks.

During the progress of the work each day's operations were plotted, the shore lines being laid down by the natural sines and cosines. Notes were also taken of the geology of the valley, and the proper authorities were consulted in reference to the trade upon the river.

FINAL REPORT AND METHOD OF WORKING UP THE NOTES.

In the preliminary report the results of the survey have been intentionally excluded in order to bring them together in the final report.

The final report will supply the results of the survey under the heads of the physics, geology, and hydraulics of the river.

It will also include a statement of the obstructions to navigation and the method of improving the river.

The resources of the valley of the Arkansas and the statistics of trade will be stated, so far as the facts relating to these subjects can be ascertained.

The following maps are in preparation:

I.—Eighty-one sheets of the original field maps, upon a scale of two hundred feet to one inch, exhibiting the topography of the banks, position of shoals, and the soundings, reduced to a plane of three feet above low water.

II.—Reduced maps of the above upon a scale of two miles to the inch.

III.—An index map upon a scale of about six miles to one inch, showing the position of each sheet.

IV.—Small topographical sketches of special localities to accompany the report.

V.—Sketches of the localities of proposed improvements.

The following profiles are in progress:

I.—A profile of the entire line, showing the high and low water lines, and the bed of the river, on a horizontal scale of about one inch to ten miles.

II.—Profiles of the cross section of the river and valley at all points where discharge measurements were taken.

The following diagrams are in preparation:

I.—Showing section, velocities, with statements of the divisional and aggregate discharges of all the cross sections.

II.—Diagrams representing the horizontal and vertical parabolas of sub-surface velocities.

III.—Diagrams representing the horizontal parabolas of velocities.

IV.—Daily oscillations of the river.

Tables of oscillations, velocities, levels, and discharge measurements will be prepared.

The above statement includes the principal subjects of the report nearly in the order in which they will be taken up.

Very respectfully, your obedient servant,

S. T. ABERT,
Assistant Engineer.

Colonel J. N. MACOMB,
Corps of Engineers U. S. A.

K.

The following is a statement of the amounts disbursed by Colonel J. N. Macomb, Corps of Engineers, during the fiscal year ending June 30, 1869, under the several heads of appropriation named:

Snag-boats and apparatus for clearing western rivers.....	$49, 130. 28
Examinations and surveys on western and northwestern rivers, &c.	13, 014. 67
Improving Mississippi, Missouri, Arkansas, and Ohio rivers,	141, 903. 79
Repairs, preservation, extension, and completion of certain public works, &c.	88, 019. 35
Total	292, 068. 09

Respectfully submitted.

J. N. MACOMB,
Colonel Engineers, Brt. Col. U. S. A.,
Gen'l Sup't U. S. Snag-boats and Western River Improvements, &c.

Brevet Major General A. A. HUMPHREYS,
Brig. Gen'l and Chief of Engineers, U. S. A.

Estimates to accompany the annual report of Colonel J. N. Macomb, Corps of Engineers and Brevet Colonel U. S. A.

IMPROVEMENT OF THE WESTERN RIVERS, EXCEPT THE OHIO RIVER.

Officer in charge, Colonel J. N. Macomb, Corps of Engineers, brevet colonel United States Army, assisted by Brevet Major C. R. Suter, captain Corps of Engineers, United States Army.

The operations have been carried on under the several heads, as set forth below, in the detailed estimates for continuing the works during the fiscal year ending June 30, 1871.

The most sanguine expectations, as to the success of the boats in this service for the past year, have been fully realized; but it is to be regretted that no specific appropriations were granted, in accordance with previous estimates, for adding to the boats and machinery for pushing forward more rapidly this useful work.

I.—*Construction of snag-boats and machinery.*

There being no new appropriation under this head, it became necessary, after building one light-draught snag-boat, to apply the remainder of the original appropriation to meet the current expenses of running and working the boats in the service, as authorized to be done in the act grant-

ing the appropriation. The original fund will be thus exhausted during the current fiscal year, ending June 30, 1870. During the fiscal year ending June 30, 1871, there will be required the following amounts, viz:

For repairs and painting of the four snag-boats and one dredging boat, and for keeping up the snag-lifting and the dredging machinery in a state of efficiency, for these five boats, $9,500 each	$47,500
For building *three* additional boats, with all the machinery and apparatus for destroying snags, blowing up and removing wrecks, rocks, and any other obstructions to the navigation of the western rivers—two large boats, at $75,000 each	150,000
And one boat of light draught, to be fully equipped as a dredging boat	59,000
Office expenses, pay of assistants, &c., applicable to this appropriation	14,000
	270,500

II.—*Examinations and surveys.*

The funds under this head remaining on hand will be all absorbed in the current year, in finishing the maps and reports of the surveys of the Missouri, Mississippi, and Arkansas Rivers, that have thus far been made.

As additional surveys will be required in extending the field of operations of the snag-boats, a new appropriation of $25,000 is respectfully recommended, as applicable to the "Improvement of the Western Rivers, &c.," in the charge of Colonel Macomb, Corps of Engineers, during the fiscal year ending June 30, 1871.

III.—*Improving the Mississippi, Missouri and Arkansas Rivers.*

The work under this head has consisted of removing and destroying snags, cutting trees to prevent the forming of snags, and in dredging bars in these rivers, and has been pushed forward vigorously during the last fiscal year, by laying out the field into districts, and keeping the boats at work, as nearly together as possible, so as to admit of more easy supervision. In this way, a large amount of work was done on the Mississippi River during the winter and on the Missouri during the summer. The work on the Arkansas, requiring a boat of very light draught, was begun as soon as the boat was ready for the service, and has been continued, with good progress, since the month of May, 1869.

The tabular statements accompanying the annual report upon these improvements are confidently referred to, as showing a satisfactory exhibit of what was accomplished during the last fiscal year. Should a further appropriation be granted for these works, it is proposed to continue the same system of operating, and to extend the field of these improvements in proportion to the means made applicable thereto.

The following is an estimate of funds required under head III:

For working the five boats now owned and actively employed by the government in these improvements, viz: four snag-boats and one dredging boat, current expenses for the months of March, April, May and June, 1870, being the latter part of the present fiscal year, $4,000 a month for each boat, five boats	$80,000

Which it is hoped may be granted at an early day, soon enough to avoid the necessity of laying up these boats, now so usefully employed.	
And for the current expenses of these five boats during the fiscal year ending June 30, 1871	$240,000
For office expenses, and pay of assistants	15,000
The above estimate is for the active and useful employment of the boats *now owned* for the improving of these western rivers, to the end of the fiscal year, June 30, 1871.	
If money for building the other three boats should be granted, there will be required for the current expenses of running and operating them during the last eight months of the fiscal year ending June 30, 1871	120,000
Making under the head of "Improving," &c., a total of	455,000

RECAPITULATION.

Amount asked for under the several heads, as follows:	
For construction and repairs of snag-boats, &c	$270,500
For examinations and surveys on the works under the charge of Colonel Macomb,	25,000
For improving Mississippi, Missouri, and Arkansas Rivers,	455,000
Total	750,000

All of which is respectfully submitted by your most obedient servant,

J. N. MACOMB,
Colonel Engineers, Bvt. Col. U. S. A.,
Gen'l Supt. U. S. Snag-boats and West'n Riv. Imp'ts.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen'l and Chief of Engineers, U. S. A.,
Office of Chief of Engineers, Washington, D. C.

M 1.

OFFICE OF WESTERN RIVER IMPROVEMENTS,
No. 4, PUBLIC LANDING,
Cincinnati, Ohio, November 2, 1868.

GENERAL: I beg leave herewith to lay before you the report of Brevet Major C. R. Suter, captain Corps of Engineers, in relation to the Kansas City bridge, and, at the same time, to express the hope that the course which he suggests in regard to charters for bridges over the great navigable rivers of the country may be adopted.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel of Engineers, Brevet Colonel U. S. A.,
In charge Western River Improvements, &c.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army,
Headquarters Corps of Engineers, Washington, D. C.

OFFICE WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, October 20, 1868.

COLONEL: In accordance with your instructions directing me to inspect and report on the bridge over the Missouri River at Kansas City, Missouri, I have the honor to report as follows:

In pursuance of your orders I left Cincinnati on the 5th October, 1868, arriving at St. Louis the next day. From this date to the 10th October I was engaged in collecting information concerning the bridge from pilots and captains engaged in navigating the Missouri River. On the 11th October I left St. Louis for Kansas City, in company with Mr. M. A. Bryson, representative of the central committee of the Mississippi Valley river improvement convention. The 12th October was spent in examinations at Kansas City. On stating to the officers of the bridge company the object of my mission, they very courteously gave me all the information in their power, allowing me to examine their maps and plans, and to take copies of such as were necessary to make my report intelligible. Two tracings thus obtained are appended. One shows the general plan of the locality, the other shows the site of the bridge on a larger scale. On the 13th October I returned to St. Louis, which place I left on the 14th, arriving at Cincinnati on the 15th.

Appended to this report is a paper signed by a large number of pilots, captains, and owners of steamers running on the Missouri River, which will give you an idea of the feeling of the river interest on this question.

The Kansas City bridge is situated at Kansas City, Missouri, about one and a half mile below the mouth of the Kaw or Kansas River. It is designed at a crossing for the Kansas City and Cameron railroad, a branch road connecting the Missouri Pacific and Hannibal and St. Joseph railroads. The North Missouri railroad, in process of construction, will also cross the Missouri on this bridge.

It is intended to be used both for trains and for wagons. The superstructure is a modification of the Warren girder; the piers are built of limestone; width of roadway twenty feet. The spans are as follows:

Beginning at the Kansas City end, the first or shore bay is 67 feet; the second is 133 feet. Then comes the draw, the double span being 363 feet; the next span is 200 feet, the next 250 feet, the next 200, and the last 175. All these dimensions are measured on the axis of the bridge.

The first pier is 6 feet thick; the second 8 feet. The first pier, which is circular, is 30 feet in diameter, the next in order is 8 feet thick, and the four others are each 7 feet thick. The bottom chord is 10 feet above the highest known water-mark, the extreme range of water at this place being 37 feet, and the ordinary range 20 feet. The faces of the piers have a batter of $\frac{3}{4}$ of an inch to the foot. They measure 50 feet in length at low water. The cornice projects 1 foot. The pivot pier has vertical faces, with a cornice 2 feet thick. The piers make an angle of 72° with the axis of the bridge. Above and below the pivot pier are masonry rests for the ends of the draw when open. Their faces are parallel to the piers, and they are to be connected with the pivot pier by a framework of timber faced vertically like the sides of a ferry slip. Beyond the last pier the bridge is carried 2,373½ feet across the bottom lands on trestles, making the total length of the bridge 3,761½ feet.

The Missouri River makes a large bend at this point, in consequence of which a large body of water always moves along the concave shore, right bank. There is always twenty feet or more of water to be found under the draw. The river has tended constantly to wear into the concave bank, as is shown by the different shore lines marked on the large map. This is partially stopped now by the stone revetment of the bank,

which is being carried up to the mouth of the Kaw. When this is completed, the channel line may be regarded as constant. From my observations I judge that the piers have been built parallel to the direction of the current at low water, but it is evident from the shape of the shore near the bridge, that there must be a constant tendency of the current to cross to the left bank a little above the site of the bridge. At the time of my examination the current was about two and a half miles an hour, the river being four or five feet above extreme low water. In ordinary stages, the velocity being only from two to three miles an hour, the attraction of the bank for the particles of water nearest it is sufficiently powerful to keep the channel near the right bank. At high water, however, the velocity runs as high as eight or nine miles an hour, and the attraction of the bank is so far overcome that the main body of water passes off in the direction of the fourth and fifth piers of the bridge. On a chart showing comparative sections of the river bottom at different stages, this action was very plainly shown by the depth of erosion at the point mentioned above. The depth of this point was much greater than that under the draw, which was, however, deep enough to show that a considerable body of water passed through it even at high stages of water. The sheet of water which in floods pours across the low lands of the point opposite Kansas City must deflect the surface current to a certain extent, and probably gives it the same direction as at low water, viz., through the draw. How far below the surface this action extends I cannot undertake to say, but it is reasonable to suppose that a boat would be deep enough in the water to feel the influence of the powerful under-current which would also certainly make its way to the surface from time to time in boils, eddies, &c. With a current of eight miles an hour, a boat must be going at the rate of at least twelve miles to keep steerage-way on her. On approaching the bridge she must hug the right bank to run through the right-hand draw. Just before reaching the bridge she is obliged to turn slightly to the right to pass the draw, and at this moment she will feel the influence of the under-current setting across the river. The effect of this will be to slew her stern around and send her through the draw more or less side foremost. The draw being narrow, a long boat will be very apt to strike on the center pier, and as she would be going at great speed she would certainly be sunk by the collision.

I think this represents fairly the state of the case; although not having seen the bridge at high water, I cannot say positively. I am, however, confirmed in my opinion by the statements of all the pilots I have conversed with on the subject. Their description of the difficulty which they encounter corresponds with what I have stated above, and they all say that when the center pier is built no large boat will venture to drop through head foremost. The time lost in turning round and dropping through stern foremost is a serious matter, and there seems to be no earthly reason why boats should be subjected to this delay and danger. I was informed that several boats have already struck on the cribs filled with stone, which are designed for the foundations of the draw rests. Below the present site points could have been found more advantageous as bridge locations than the one adopted; but they all have this disadvantage, that the channel-way is not stable, but shifts from one side of the stream to the other. This is avoided in the present location by the concavity of the bank, which always gives an ample channel depth under the draw. The bridge company are obliged by their charter to use a pivot draw-bridge, which no engineer, I think, would have recommended in this case. It was an excellent locality for using counterbalanced

draws, with a half span of, say one hundred and twenty-five feet, giving a clear way of two hundred and fifty feet, which would have been sufficient to have allowed the largest boats to pass through sideways, if necessary. The act of Congress authorizing the construction of this bridge requires a pivot draw-bridge over the main channel of the river, with spans of not less than one hundred and sixty feet in the clear on each side of the pivot-pier of the draw; and also that the adjoining spans shall not be less than two hundred and fifty feet. If, as seems most rational, the expression "in the clear" was meant for the perpendicular distance from the face of one pier to the face of the next—that is, the width available for passing boats, then the first condition has not been complied with. The width at extreme low water is only 151.76 feet, and at high water only 151.69 feet. In this latter case the cornices of the piers would only be about eight feet above the water, take off nearly three feet of the available width. Measured on the line of the axis of the bridge, these distances are 159.50 feet at high water, and 159.57 feet at low water.

The spans adjoining the draw are respectively one hundred and thirty-three and two hundred feet, instead of two hundred and fifty feet, as called for.

The bridge presents no obstacle to an ascending boat, which can pass through both spans of the draw equally well. At high water a descending boat cannot risk the passage of the left span at all, and can only run the right hand one at great risk. It would be impossible for a descending boat to pass through this bridge at night. At the time of my examination the first two piers and the abutment were completed, and the superstructure over them finished. The foundations for the draw rests were in position, and the caisson for building the center pier was being placed. The next pier was finished. The next two were in process of construction. The two last piers were up, and the superstructure over them completed.

In submitting these facts I cannot refrain from calling your attention to the bad results likely to ensue from the manner in which these bridge charters are granted. The act of Congress authorizing the construction of the Kansas City bridge included several others on different rivers, all of them being subject to certain general conditions which are not general in their application, nor sufficiently complete, if applicable. My views on the requirements of this particular bridge I have already given, and every bridge built is necessarily subject to special conditions suitable to the particular case. The probability is that within the next few years many railroad bridges will be needed, unless proper precautions are taken. They will almost destroy our river commerce, by presenting obstacles which no boat will dare to pass. There is no necessity for this, as bridges can be built which will leave the river navigation safe and untrammeled. My own opinion is that, before granting authority to any company to build a bridge, the subject should be submitted to an impartial board of military or civil engineers, and the subsequent legislation should be in accordance with their decisions.

I am, colonel, very respectfully, your obedient servant,

CHAS. R. SUTER,
Brevet Major U. S. A., Captain Engineers.

Colonel J. N. MACOMB,
United States Engineers,
in charge of Western River Improvements.

A.

ST. LOUIS, MISSOURI, *September* 28, 1868.

GENERAL: The cities of the valley return their warmest thanks for the large share of the million and a half.

The bridge over the Missouri River at Kansas City, when completed, will make navigation almost or altogether impossible.

The builders are violating the charter granted by Congress.

The citizens of St. Louis and other cities, and the members of Congress, desire you to send some competent engineer to immediately examine and report the facts to the Attorney General. If you will order one or more of the engineers here, I will accompany them, and render them every aid, and pass them over the railroad.

Please answer immediately.

Your friend,

M. A. BRYSON.

Gen'l A. A. HUMPHREYS.

True copy:

J. N. MACOMB,
Colonel Engineers, Brevet Colonel U. S. A.

B.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., October 2, 1868.

COLONEL: The inclosed copy of a letter to these headquarters from M. A. Bryson, esq., dated September 28, 1868, in relation to the bridge over the Missouri River at Kansas City, is transmitted for your information and for report.

With a view of obtaining all the facts of the case, you will direct your assistant, Brevet Major C. R. Suter, corps of engineers, to proceed at once to Kansas City, and make the necessary examinations, &c.

By command of Brigadier General Humphreys.

Very respectfully, your obedient servant,

J. C. WOODRUFF,
Brevet Brigadier General U. S. A.

Colonel J. N. MACOMB, *Corps of Engineers,*
box 825 *Cincinnati, Ohio.*

True copy:

J. N. MACOMB,
Colonel Engineers, Brevet Colonel U. S. A.

C.

OFFICE WESTERN RIVER IMPROVEMENTS,
Cincinnati, Ohio, October 5, 1868.

MAJOR: For the purpose of getting all possible information in relation to a bridge which, it is understood, is about to be constructed from Kansas City, Missouri, over the Missouri River, to the probable injury of the navigation of that stream, you will proceed at once to St. Louis, Missouri, and confer with Mr. M. A. Bryson at that point, and proceed thence to Kansas City, Missouri, in order to ascertain the location and proposed plan and elevation of the bridge, and all facts bearing upon the question of its relation to the navigation, to enable you to prepare a full report upon the subject.

On accomplishing this duty you will return to Saint Louis, Missouri, and without further delay there than the business in question may call for, you will proceed thence to Cincinnati, Ohio, and continue your duties with me at this office. I inclose for your information the within

copies of two papers just received from the Headquarters of the Corps of Engineers.

I am, very respectfully, your obedient servant,

J. N. MACOMB,
Colonel Engineers, Brevet Colonel U. S. A., in charge Western River Improvements.

Bvt. Major C. R. SUTER,
Captain of Engineers, U. S. A.

D.

We, the undersigned, owners, captains, and pilots of boats navigating the Missouri River, hereby respectfully certify that the "Kansas City bridge" is not being built at an accessible point, *as provided by the law*, and greatly hinders and endangers navigation at all times, but especially during high water, when it is impassable with any degree of safety. And we hereby pledge our best endeavors to effect its removal.

W. P. Lamothe, pilot and owner.
P. Yore, pilot and owner.
James A. Yore, pilot and owner.
David Haney, pilot.
E. W. Gould, owner.
J. P. Fitzgerred, owner.
V. N. Yore, pilot.
H. H. Symones, captain and pilot.
Grant Marsh, pilot.
T. S. Calhoon, captain and owner.
John R. Adner, pilot.
Henry Keith, pilot.
D. H. Silver, captain and pilot.
J. W. Gartrel, pilot.
William Conley, pilot.
Fred. Dozier, pilot and l. b. owner.
J. R. Sousby, pilot.
David L. Keiser, pilot.
T. K. Voorhees, captain.
A. Burbank, pilot.
R. G. Baldwin, pilot.
A. Reeder, pilot.
L. Burbank, pilot.
John T. Doran, pilot.
J. E. Tebeau, pilot.
John T. Stansbury, pilot.
Joseph Fect, pilot.
William C. Jamison, pilot.
Joseph Throckmorton, captain.
Captain Ben. Johnson, captain.
Thomas W. Scott, pilot.
H. G. Carson, captain.
J. D. Dooper, pilot.
C. W. Blunt, pilot.
John W. Gilham, pilot.
Charles A. Wiseman, pilot.
William W. Baker, pilot.
Thomas C. Bigger, pilot.
James W. Gunsoller, captain and pilot.
William Throckmorton, pilot.
J. W. Malin, captain.
George Vickers, pilot.
Edward S. Herndor, captain.
William S. Herndor, pilot.
John La Barge, captain.
James Gunsallas, captain.
H. K. Hazlett, captain and pilot.
W. R. Carter, owner.
J. H. Coun, owner.
J. S. Carter, owner.
Frank Carter, owner.
Henry S. Carter, owner and captain.
Joseph La Barge, jr., capt. and pilot.
Joseph C. La Barge, pilot.
W. W. Ashley, pilot.
A. G. La Barge, pilot.
Thomas J. La Barge, pilot.
J. Cathright, captain.
R. Porter, owner.
W. R. Massie, pilot and owner.
Sam. Constant, pilot.
E. B. McPherson, jr., owner.
M. Hillard, owner.
John G. W. Poonce, pilot.
Lawrence Wessells, pilot.
John A. Schwab, pilot.
William M. Young, pilot.
R. J. Whitledge, owner.
George W. Boyd, captain.
M. H. Cropster, captain.
E. Spencer, captain.
Samuel Ryder, captain.
Robert B. Bailey, captain.
N. P. Constandt, owner.
Henry McPherson, captain and owner.
C. L. Sombart, owner.
Thomas W. Brylan, owner.
William W. Ater, owner.
William D. Shunks, captain.
C. J. Rogers, captain and owner.
D. Baldwin, pilot.
G. W. Vaughn, pilot.

E.

AN ACT to authorize the construction of certain bridges, and to establish them as post roads.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be lawful for any person or persons, company, or corporation having authority from the States of Illinois and Missouri for such purpose, to build a bridge across the Mississippi River at Quincy, Illinois, and to lay on and over said bridge railway tracks for the more perfect connection of any railroads that are or shall be constructed to the said river at or opposite said point, and that when constructed, all trains of all roads terminating at said river at or opposite said point shall be allowed to cross said bridge for reasonable compensation, to be made to the owners of said bridge, under the limitations and conditions hereinafter provided. And in case of any litigation arising from any obstruction or alleged obstruction to the free navigation of said river, the cause may be tried before the district court of the United States of any State in which any portion of said obstruction or bridge touches.

SEC. 2. *And be it further enacted*, That any bridge built under the provisions of this act may, at the option of the company building the same, be built as a drawbridge with a pivot or other form, or with unbroken and continuous spans: *Provided*, That if the said bridge shall be made with unbroken and continuous spans, it shall not be of less elevation in any case than fifty feet above extreme high-water mark as understood at the point of location to the bottom chord of the bridge, nor shall the spans of said bridge be less than 250 feet in length, and the piers of said bridge shall be parallel with the current of the river, and the main span shall be over the main channel of the river, and not less than three hundred feet in length: *And provided also*, That if any bridge built under this act shall be constructed as a draw-bridge, the same shall be constructed as a pivot draw-bridge with a draw over the main channel of the river at an accessible and navigable point, and with spans of not less than 160 feet in length in the clear on each side of the central or pivot pier of the draw, and the next adjoining spans to the draw shall not be less than 250 feet, and said spans shall not be less than thirty feet above low-water mark, and not less than ten above extreme high-water mark, measuring to the bottom chord of the bridge, and the piers of said bridge shall be parallel with the current of the river: *And provided also*, That said draw shall be opened promptly, upon reasonable signal, for the passage of boats whose construction shall not be such as to admit of their passage under the permanent spans of said bridge, except when trains are passing over the same, but in no case shall unnecessary delay occur in opening the said draw during or after the passage of trains.

* * * * * * *

SEC. 10. *And be it further enacted*, That any company authorized by the legislature of Missouri may construct a bridge across the Missouri River at the city of Kansas, upon the same terms and conditions provided for in this act.

* * * * * * *

SEC. 13. *And be it further enacted*, That the right to alter or amend this act so as to prevent or remove all material obstructions to the navigation of said river by the construction of bridges, is hereby expressly reserved.

JULY 25, 1866.

M 2.

HEADQUARTERS DEPARTMENT OF THE MISSOURI,
OFFICE CHIEF ENGINEER,
Fort Leavenworth, Kansas, February 7, 1869.

SIR: I have the honor of calling your attention to a new method for channeling through sand-bars which obstruct the navigation of western rivers. The method appears feasible and worthy of trial. If successful it may be made the means of relieving the government from further expenditure for dredging, by making it to the advantage of the steamboat owners to adopt it and thus enable each steamer to force a channel for herself over the worst bars.

The method was suggested by observing the effect produced on sand-bars by slightly increasing the velocity of the current over them, and at the same time loosening the sand to make it wash easier—objects now attained by river men, when working over a bar, in a very clumsy and not always effective manner, viz, by the use of spars, forcing the bow of a boat on a bar, thus loosening the sand and giving the current sufficient strength to carry the loosened material away.

I propose to loosen and wash away the material of bars by forcing directly upon it several streams of water, discharged from the hull of a boat. The water to be drawn from near the stem of the boat, through a suction pipe, and by a forcing pump driven out forward through pipes or hose, discharging at the lower line of the hull directly on the bar.

Any required volume and velocity can be given these streams that experiment may show necessary.

The machinery can be of the simplest kind. That which I have designed will consist of a centrifugal suction and forcing pump driven by an auxiliary engine, and of the necessary supply and discharge pipes with their connection. The whole will occupy but a small space in the forward hold of the boat (a space seldom economized) and will be entirely out of the way. The cost will range from $2,000 to $5,000, dependent on the size of pump and engine used.

To use this proposed method, the pilot of the boat, after selecting his point of crossing, will run her head on to the bar and keep her in position; the washer will then be set at work and the boat continually forced ahead by her wheels, until a crossing is effected.

By turning the nozzles of the discharge pipes slightly backward, I make the escaping water aid the boat forward; the streams discharged dig up the sand and wash it back far enough to bring it within range of the wheels, which latter then wash it past the stern of the boat. Should this method prove successful, I believe that it will be of great advantage to river commerce.

It cannot be expected that the government will every year spend thousands of dollars to remove sand-bars which re-form at every flood. Those interested in river navigation ought to make themselves independent of such obstructions, and of government aid, but they will not entertain the idea until forced to do so.

By this method, or by one similar, steamboat men might be placed in position to help themselves as they ought to do, and the moneys appropriated by Congress for dredging, &c., would be disposable for more important, permanent improvements.

If this meets with your approval, I would respectfully suggest that a trial be made on the boat to be employed on the Upper Missouri, next season. If valuable for the purpose intended, it will be the means of lengthening the working season.

I am engaged in perfecting the plan of machinery to be used, and if you desire will forward drawings.

I have the honor to be, very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers and Brevet Major U. S. A.

Brt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers U. S. A.,
Washington, D C.

HEADQUARTERS DEPARTMENT OF THE MISSOURI,
OFFICE CHIEF ENGINEER,
Fort Leavenworth, Kansas, March 3, 1869.

SIR: I have the honor of forwarding herewith, description and drawings of the machine I propose for use in removing sand-bars.

The principal parts are, the engine-pump and distributor, with the supply and discharge pipes. The engine will be supplied direct from the main boilers on the boat, and directly connects with the pump to avoid loss of power; by making the stroke short, the required velocity can be gained.

I have selected a centrifugal pump, for the reason that it gives volume and a constant flow without the use of valves and packing, liable to frequent derangement when used with very muddy water. From the best information I have been able to gain, the pump known as "Gwynne's patent," will, I think, be the proper one to use. I am corresponding with the agents, Messrs. Eads and Nelson, St. Louis, and in a few days expect full information.

In case no pump can be found to answer the purpose, I have designed one which I think will. I send plan and description. It would cost much more than Gwynne's, because of the expense of pattern.

The distributor is simply an arrangement for attaching the several discharge pipes to the pump. It is shown in Fig. I.

The supply pipe I propose to make the same as the cistern pipes used with steam fire-engines. It runs the whole length of the boat along the center truss of the hull, and rests on the ribs. A hand valve at the outer end shuts off the supply of water. Its connection with the pump is shown in Fig. II.

The discharge pipes may be strong leather hose or iron pipe, and will be connected with the distributor and with the nozzles by the ordinary method in use for hose connections.

The nozzle is shown in Fig. I. It is arranged to discharge forward when the boat is headed down stream, and backward when going up. It is turned by an iron bar represented in the figure. It discharges at the lower line of the hull and directly on the sand to be moved.

The pump which I have designed consists of an outer cylinder L, clamped by connecting bolts between the two iron plates, (—) forming the top and bottom of the pump, making a water-tight cylindrical box. Within this and concentric with the outer cylinder is the inner casing *c*, which revolves about a vertical axis A, and carries with it six vanes, (XXI.) These vanes are arranged to slide alternately from and to the center, the motion being directed by two eccentric guides *a b*.

The water-way, which is between *c* and *d*, is contracted to give between the supply D, and discharge E, pipes, the guides forcing the vanes into the inner cylinder to pass this point. Between R and S, the vanes fill the whole water-way, forcing the water out in front, and by suction

filling the space left behind. To relieve the axis, friction wheels are placed under the revolving cylinder, one of them, K, being shown in Fig. II. A heavy fly-wheel is used to regulate the motion. The pump may be made of any required size. The one represented is intended to throw 50 barrels per minute, and will, I think, be large enough.

The drawings are made to a scale. The pump is similar to that designed by Dietz, but I have introduced several modifications of his plan. I have represented plain vanes; it might be well to curve them as in Appold's pump. The inner guide might perhaps be dispensed with, the centrifugal force being sufficient to throw the vanes out after passing the discharge pipe.

A practical mechanic would no doubt make useful changes in the details of construction.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers and Brevet Major U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers U. S. A.,
Washington, D. C.

Estimated cost of machine.

200-barrel pump, Gwynne's patent	$500 00
Engines (double) with coupling, (probably)	1,000 00
Distributor, including pattern, (probably)	100 00
Four nozzles and boxes, at $25, (probably)	100 00
	1,700 00
Cost of pipes, (no reliable estimate.)	
Cost of docking boat, about	200 00
Cost of setting up machine	....

Probable total cost, $2,500 to $3,000.

These estimates are only approximate and founded on the best authority I have been able to get for cost of castings, patterns, hose and labor.

If some pump at present in use is not adopted, the cost of pattern for a new design will be about $1,000, to be added to above.

M 3.

WASTE LANDS, MISSISSIPPI RIVER.

Memorial of Brevet Brigadier General B. S. Roberts, on a plan for reclaiming the waste lands of the Lower Mississippi.

WASHINGTON, D. C., *January*, 1866.

SIR: The magnitude of the subject I propose in this memoir to bring to your notice, and through you to the consideration of Congress, and the vast interests involved in reclaiming and converting to the use of the world, the delta lands of the Lower Mississippi Valley, would suggest a sufficient excuse, were any necessary, for this manner of expressing my views on this subject, and attracting the attention of the country to the

unappropriated elements of prosperity in the material of the waters of Mississippi, borne on by its eternal flood and constantly wasted in the tides of the Gulf of Mexico.

I here propose, briefly, to suggest my undoubting conviction that a new plan of diking the Lower Mississippi in connection with a system of water-weirs and gates, so constructed at proper distances in the levees of the river that during all the seasons of great floods, vast volumes of the waters of the river, thick with the delta-making material borne down in the Missouri and other great rivers of the northwest, may be turned off to overflow the extensive swamps and morasses, and fill the lagoons and lakes abounding between the table lands and the proper alluvial bottoms of the Lower Mississippi Basin, depositing in them and creating from these waters new and rich delta-lands, and by degrees raising them to the level of the stream when in flood. In this manner it is proposed to redeem them from their present waste, turn them to bottoms exuberant in richness for the culture of cotton and sugar, relieve the country from their fatal malarias, and create sanitary and productive soil where morass, swamps, stagnant lagoons, and lakes, are the fruitful causes of the contagions and pestilences of this region.

The fact that an engineer of the army, distinguished for capabilities as a general, and in scientific and practical engineering, has been charged by you with the repairs of the levees, neglected and destroyed since the beginning of the rebellion, and sent to superintend their reconstruction, suggests clearly to my mind your views of the powers of the government to take in hand any measures of this nature, involving and facilitating commercial intercourse with the many States washed and traversed by the tributaries of this great "inland sea," and all emptying their floods through this great lower basin of the Mississippi into the Gulf of Mexico.

How far the government, under its constitutional powers "to regulate commerce between different States," can, incidentally, in improving the navigation of this tide-water river, introduce improvements by any new system of diking, releasing the main flood-waters from existing banks and beds, so as to divert their creative material of delta into the swamps, lagoons, and lakes of the States of Arkansas, Mississippi, and Louisiana, and reclaim them from wastes productive only of contagions, fevers, and pestilences, Congress must decide. But it is in my judgment, offered, however, with diffidence, as clearly within the powers of Congress as it is to pass laws of quarantine and health, or laws to protect life and preserve health on steamers that navigate this river on the high seas. Preventive measures against pestilence and epidemics at home are, or ought to be, as much under the control of Congress, as legislation to close our harbors and rivers against their importation from abroad.

At all events, the right of the government to improve navigation of rivers that flow into the sea is conceded; and under this concession I shall proceed to show that the plan I propose goes directly to this point, and is one of the most economical and practical the government can adopt.

Under the present regimen of this river, as partially regulated by existing systems of dikes, the waters, charged with their rich and fertilizing material forming our deltas, are not permitted to spread themselves over the great alluvial bottoms of the States I have mentioned, but are borne on into the Gulf, depositing their material near the great mouths, and constantly forming new land there.

The heavier water of the sea, and the stronger tide and stream of the

Gulf, throw back this material, and deposit it in and about the confluence of the fresh with the salt water. Here it creates and increases bars, setting back, as dams set back, the waters in their channels, and in process of time raises the water in the main beds above their banks, requiring continually higher and stronger dikes to prevent overflow and the destruction of plantations whose levels are below high-water lines.

These are the unchangeable laws governing the creation and growth of great alluvial bayous and bottoms. These are nature's laws, and can only be partially changed by artificial means, in a greater or less degree, however, as the skill and ingenuity of man practically applied may alter them.

The geography of the great Mississippi Bayou is particularly favorable to the successful application of skillful engineering, so as to control the regimen of this river, and, in the progress of time, aiding and directing its flood to accomplish, by its own power and perpetual laws, the regeneration of its wastes of marsh, swamps, morass, lagoons, and lakes, and make them prolific sources of wealth.

The system should begin up the river, where dikes are necessary to preserve the plantations and cultivate lands from overflows by high water. From these points to the mouth of the river waste weirs of timber, with revetted aprons of plank, should be constructed in the levees, so as to carry off the flood-waters into the swamps, marshes, and lagoons, depositing in them the delta-making material of every flood, while the water by evaporation, spreading out over greater surface, wastes itself, is drank up by the soil, or filters itself through the sands and is lost in other outlets to the Gulf. The proportion and number of the waste-weirs must be regulated by the topography of the country, the extent of morass, swamps, lagoons, and lakes to be filled. The most thorough surveys by practical and skilled engineers should be made to determine their number and the volume of water they should waste.

The cost of such waste-weirs or aprons, at 500 or even 1,000 points along the length of the levees from Tennessee to the mouth of the river, would be an insigificant figure above the cost of the earth levees as now constructed. They would, in fact, form only another plan of diking by using at intervals timber instead of earth, built at a less height, revetted with plank aprons, over which the water with its delta-making material will flow into the low swamps and morasses during all seasons of flood.

Compared with the benefits to the country, it would be economy should they cost millions; for in all time they would be creating new and rich lands, and precipitating the time when, in God's unchanging creative laws, to prepare the earth for the growth and development of man under the divine decree to multiply and replenish the earth, "the mountains shall be made low and the valleys exalted."

Illustrations without number are conclusive of the truth of my theory and its practical application. Few men have lived long in the lower basin of the Mississippi River without observing its realization in the formation in a few years of new islands and lands whenever heavy floods, and the drift they often lodge in the beds of the river, have changed the direction of the current of the stream so as to form eddies. Here the force of the stream ceases to carry on the delta-making material with its current. In a single flood large deposits are precipitated, forming the foundation for a new island, increasing in its proportions with each succeeding flood, and in the lifetime of a single individual growing to the magnitude of a planting habitation. In fact, these changes are so sudden, and the accumulation of delta so extraordinary in a very few years, that pilots of the Lower Mississippi, absent or

unemployed for such periods of time, are lost in their bearings, and must study the new landmarks to resume with any degree of safety the helm of the steamers that thread the changing channels of this mighty river.

It must be conceded, then, that much of the delta-making material in the waters of the Mississippi, that would be borne into the Gulf in its natural flow, can be spread out by artificial means, and deposited in the swamps, marshes, morasses, lagoons, and bottom lakes, of its lower basin. This will lessen so much of the formation of new land and bars, at the embouchures into the Gulf; and while it lessens the constantly accumulating and elevating alluvium there, that sets back the water in the bed of the stream, increasing the obstruction to navigation by enlarging the bars and necessitating the construction of higher dikes to save the lower plantations from inundation, it will at the same constant rate make new formations and new soil in the morasses and swamps above, and in time raise all the upper basin to a higher level, drain or expel the waters of its lagoons and lakes, and reclaim for the purposes of agriculture the most favored valley of the two hemispheres for the growth of cotton and sugar. Such is the rationale of fact, so far as we know of the past. Reason and the geological history of all similar great alluvial basins confirm its truth. In the progress of civilization, science and man, the elements are made to subserve his interest and to aid in the preparation of the wilderness and waste places for the expansion of empire and the growth of the human race.

In the old world the alluvium of Holland and other low countries have been improved and made the most productive and remunerative lands of that continent. Different systems for drainage have been adopted, but they have all been effected at enormous labor during long periods of time, and at almost fabulous costs. In the low lands of Holland large lagoons and lakes were emptied by the process of pumping their waters to higher levels and draining them from such positions by canals and ditches; but years were spent in this slow process, and royal exchequers exhausted. But the vast extent of morass and swamp, and the great volume and surface of water in the lagoons and lakes in the Lower Mississippi Basin, would render all mechanical means unavailing in the regeneration of wastes of their magnitude. For this reason I propose to subjugate to use for this great achievement the mighty power of the everlasting flood of the father of waters. That is unchanging, and by its own laws of flow and evaporation and deposit will in less time perform this plan of reclaiming the wastes of this great alluvial basin than the application of the powers of all known mechanical forces, directed by the highest practical skill of man. I therefore propose "to lay my hand on the main" of this torrent, and, bridling its accumulated waters, tame their normal insubordination, and convert its never failing power to cumulative use that will profit mankind in all progressive time.

This proposition and its theory will doubtless present itself in a novel and possibly startling sense to many scientific and practical engineers, unfamiliar with the geological and topographical peculiarities of the lower basin of this valley, the origin of the principal floods of the Mississippi and its great tributaries. It is, therefore, proper that I should bring to their notice and ask their attention to the habits of all these main supplying waters, and to their influence over the regulation of the great yearly floods that spend their active force and power before reaching the lower bottoms and basins of their "*agua madre.*"

The floods of these tributaries have their origin in rain-tables in remote

latitudes from each other, and they are consequently seldom contemporaneous and in confluence.

The melting snows, and the rains that swell the Ohio and the water-table of the western slope of the Alleghanies, and the eastern dip of the rolling lands and prairies of Illinois, Indiana, and Ohio, occur long before the flood of the Arkansas, that has its cause in the melting snows of the Sierra Madres of New Mexico and Colorado Territories. The Illinois River, that drains the central and northern prairies of the State, is seldom at its full flow when the melting snows of the extreme northwest and the Hudson Bay region bring down the greater and later drainage from the upper lake country, in the clear water channel of the Upper Mississippi. But the still mightier tide, that rolls down the floods from the Yellowstone and the upper sources of the Missouri, having their cause in the thawing at a still later season of the eternal snows of the highest mountains of the Cordilleras of Russian America, has its prominent independence of all others, as it has its higher sublimity and power from the vastness of its drainage, and the magnitude of its mountain sources, in ever increasing snows deposited from the vapor of the great Pacific Ocean, borne on by the prevailing winds from that ocean's coast, and constantly precipitated on the snow-capped tops of mountains where man has not yet trodden. None of these great rivers, in their lower and broad valleys, dash down their floods with any of the fury of mountain torrents, suddenly swollen by heavy rains or melting snows; but they roll them thousands and more of miles through broad valleys of gradual and slight slope, after spending their destructive torrent force in higher altitudes and narrow mountain beds, until they meet and mingle in the still broader valley of the Mississippi bottom. Here they become tranquilized as they mix and mingle together, and swell on in greater majesty but less rapid currents through the lower basin, as if hesitating to lose their individuality in the seas that drink them up. In this basin, whose delta lands are of uniform level, they may be subjugated to the control of man, and spread out by artificial means, having lost the destructive power of torrents and floods precipitated from mountain slopes and high lands.

The rise of the flood waters of the Mississippi below the mouth of the Arkansas is always by slow degrees, seldom, I believe, to exceed four inches in any twenty-four hours. Artificial banks and dikes confine these waters in their main channel from the mouth of this river to the Gulf. These dikes are constructed with a height intended to prevent any overflow of the highest floods. It is from the mouth of this river that I propose to operate my plan, and from preceding premises my illustrations will now be made more clear.

The aprons of my waste-weirs should be constructed at medium water-lines. The increased volume of water at highest flood can be estimated, and the extent of morass, swamp, marsh, lagoons, lakes, and bottom surface it is intended to spread over, can also be calculated. The average days of floods of each year can also be ascertained. The amount of delta-making material in every thousand cubic feet of flood water can also be gathered and accurately measured. When these four, now unknown quantities, that enter into the problem of the plan are ascertained, the number and extent of necessary waste-weirs may be sufficiently approximated for all practical purposes, and the problem will be resolved.

To proceed with my demonstration: suppose the waste-weirs are in proper number, and at proper distances conducted along the entire length of dike from the confluence of the Arkansas with the Mississippi to the mouth of this last-named river, and the waters gradually rise in

flood as they reach the tops of the aprons by slow degrees, and seek slowly the lowest levels—the swamps, marshes, morasses, lagoons, and lakes of a basin of vast extent and of almost unbroken level—and in these they spread themselves out and deposit the material of the delta-making soil, producing in the fruition of its fertilizing nature the best qualities of cotton and sugar of the world. From the first apron in the series, over which the waters in the beginning of flood commence to waste by trickling over the plank revetments, so inclined as to create little or no current as the waters increase to the last of the series, the same wasting operation goes on, carrying off the great volume of the flood, and spending its accumulating force and volume by slowly wasting them as they grow, and would otherwise gain resistless strength. Thus they lose the destructive power of confined torrents and floods, as the waters spread out over the vast level surface of this delta basin, and deposit the material for delta-making soil, raising by slow but perpetual increase the elevation of these bottoms, while the water evaporates and is lost.

Perhaps it is a clearer enunciation of this problem, and better illustrates the plan, to call the system of waste-weirs *artificial rivers*, having the capacity to carry off and waste a volume of water equal, or approximating in equality, with the surplus of flood-water over the medium flow of the main channel below the mouth of the Arkansas. This is substantially my plan. The undertaking is one of great proportions, and its accomplishment would be of value that cannot be over-estimated. To reclaim the great wastes of the Mississippi basin, to eliminate the creative causes of the epidemics, fevers, and pestilences of the long, broiling, epidemical heat of summer there, to convert these wastes into the richest lands of this continent, and at the same time to improve the navigation of the embouchures into the Gulf, are not impossibilities. Nothing short of impossibilities, in their strongest sense, is too great for the energies of the government, and the skill, ingenuity, and practical science of American engineers and enterprise to accomplish. It should, in my judgment, be undertaken; time and the elements of this river are the powers and mechanics it is proposed to use, and they will as surely accomplish this purpose as the forces of nature continue in their sure unchanging laws.

It has appeared to me that the present is a profitable and propitious time to bring this subject to the attention of the country and Congress. The transitive state of things in the South, inviting in that direction the enterprise, energy, and capital of the North, the West, and the Old World, will doubtless develop in the valley of the Mississippi new systems of agriculture, and new plans for the more profitable cultivation of the principal staples of commerce of the Gulf States, cotton and sugar. Lands most productive of the best qualities of these essential necessities to all the conditions, convenience and comfort of man will be in constantly increasing demand; and nature, in its progressive creation, seems to be preparing the alluvium of our Gulf States for the supply of the world.

The logic of events should not be mistaken, and in the progress of things let us wisely apply its reasoning and prepare for a great future. The experience of the past half century is convincing proof that the Gulf States are to furnish the main supply of cotton and sugar to the world, and the deltas of the Mississippi basins have proved themselves the most productive and profitable soils for the growth of these staples of commerce. It has also proved that they are principal among the sources of revenue, and lead in the agricultural wealth that founds and perpetuates our commercial prosperity.

Should these views present this subject to your mind in a new and more important light than you have heretofore considered it, I beg to suggest the appointment of a board of engineers, eminent in science and practical engineering, to examine into the expediency of the plan here foreshadowed, and that you ask of Congress an appropriation of money to cover the necessary expenses of such surveys and examinations as will enable them to report understandingly on its practicability and estimated cost.

I am, very respectfully, your obedient servant,

B. S. ROBERTS,
Brevet Brigadier General, United States Army.

Hon. E. M. STANTON,
Secretary of War.

SCIENTIFIC DEPARTMENT, SHEFFIELD INSTITUTE,
Yale College, New Haven, Conn., December 29, 1868.

GENERAL: In January, 1866, I had the honor to present to the Hon. E. M. Stanton, Secretary of War, a memoir of a plan for reclaiming the waste swamp lands, the lagoons, and morasses of the lower basin of the Mississippi, by making use of the flood-waters of the Mississippi River. I now respectfully invite your attention to that memoir, a copy of which, published by the Franklin Institute, Philadelphia, is herewith inclosed.

That plan contemplates, for the Lower Mississippi, a change only in the system of diking the river. The existing system is intended to confine the flood-waters in one channel, so as to prevent any inundations at high flood, and to discharge all the waters of this river and its vast tributaries, with all their rich delta-making material, into the Gulf of Mexico.

The mischief of this system—its subversion of the natural law of creation in forming the delta basin of large continents, its destructive effects on the navigation of the large interior rivers of Louisiana, Florida, and Texas, by the formation of bars at their mouths, where the heavier waters of the sea, by its tides and waves, carry the delta-forming material discharged into them by the Mississippi—it was the purpose of that memoir to expose, to suggest a plan to repair it, and, in the future, to avoid its vicious and destructive effects.

Congress called for that memoir; but before it was sent to Congress, Mr. Stanton had referred it to the engineer bureau. The present Chief Engineer, as I am unofficially informed, reported against its practicability, and his criticism and objections went to Congress without, as I understand, any official call for them. No opportunity was offered me to answer them, as the engineer department did not do me the honor to inform me of its criticism, and I do not now know in what were my errors, nor by what statistics, facts and arguments they were shown.

That memoir was intended only to trace a plan for preventing floods in the Lower Mississippi, by wasting all the flood-waters of the great tributaries of the river by a system of waste-weirs in the levees, creating artificial rivers that should safely carry into the lagoons, swamps and marshes of the great basin the delta-making material; and, in time, by sure cumulative deposits, raise all these low malarious basins to the level of the highest flood-waters.

It was, in fact, the preliminary proposition to the greater engineering problem of regulating the hydraulics of the continent, and, by the skill of man, making them all co-operative in developing the wealth and com-

merce of a people resolved to establish here the empire of the world. This problem has been my study the past thirty-five years, and I have only waited the propitious time to bring it prominently to the notice of Congress, where alone the power is vested, to resolve it by experiment, and to seize and appropriate to public use the most extraordinary hydraulic resources and power geographical on the map of the world. As an educated and practical engineer, capable of comprehending the magnitude of this subject, I feel myself quite assured that the occasion now offers itself, and I therefore make haste to submit to you my further memoir of my complete plan.

Two centuries before the country west of the Mississippi and the States of Florida and Louisiana came into our possession, the French and Spanish commenced the present system of diking. It was at first a temporary expedient, to protect from overflow plantations established along the river bank, where the delta lands, from the nature of their creative process by deposit, were the highest. As this foreign population increased and planting progressed, plantations and their dikes grew together, forming long unbroken lines from the cultivable lands lowest down the river, so far up as the old creole settlers on it carried their enterprise and planting. So that this great mischief, springing from so small a beginning, when the country was purchased by our government, had grown to enormous proportions. It had wholly checked the creative process that was forming in the entire delta basin of the Mississippi new lands, by spreading its yearly flood-waters in overflow its entire length and breadth, depositing its delta sediment.

This foreign element, that first colonized along the Mississippi bank, knew nothing of the tributaries of this river, from what sources its great volume of creative delta-forming floods came, or the unchanging laws of their cumulative deposits and delta-land formations. From their loins a mixed race has sprung, more distinguished by desire and habit of luxurious ease, than by the energies and enterprise of the Anglo-American that have since founded great States, and carried civilization to the head waters of every tributary of the great Father of Waters.

The problem proposed in my first memoir was intended first to correct the mischief begun by these first colonists and planters on the banks of the Mississippi, by skillfully undoing what they did wrong; by restoring the creative unchanging laws of this river to their office, until the great delta-basin is finished, and the cotton of the world shall be growing where swamp and morass send forth their malaria and poison the air with pestilence and death.

Having enunciated the plan of reconverting the flood-waters of the Mississippi to their normal use, I now propose my plan of engineering all the waste-waters of the great lakes that discharge themselves over Niagara Falls, and find their way to the sea through the Gulf of St. Lawrence, so as to feed the Upper Mississippi, the Illinois and Ohio Rivers in their low stages, and to give them a fixed minimum supply for navigation during all seasons of drought and scarcity of water.

This problem of hydraulics is not less important than that of controlling the floods of the Mississippi, and has fewer difficulties in the way of its practical solution. It is co-operative with the other. Both are of importance that cannot be overestimated. Vast as the country is over which the engineer must run his surveys and operate all the surplus waters of the lakes, it is so geographized by nature that he has only to trace his levels, calculate his cuttings, make his estimate of costs, and the work is ready for any skillful hand to accomplish. God has made

the country so conformably to this plan that it would seemingly contravene His purposes to found a great civilization here longer to neglect it.

Lake Superior is the natural feeder of the Upper Mississippi. All its surplus waters that leap over the Sault of Ste. Marie's into Lakes Michigan and Huron, and are needed in low stages of water of that river, could be drawn from the northwest end of that lake into Rum River, one of the principal tributaries of the upper river, above the Falls of St. Anthony. Lakes Michigan and Huron mingle their waters on the same level. They are the natural feeders of the Illinois River, that has its rise in close neighborhood to Lake Michigan. All their surplus waters that empty through the St. Clair River should be drawn off through the Chicago River into the Illinois.

The surplus waters of Lake Erie that discharge themselves over the Niagara Falls into Lake Ontario should be engineered through the Mahoning into Beaver River, into the Ohio.

Nature opposes no obstacles to these three artificial rivers, that with little cost could be created with the capacity required to take the surplus waters from the three great water-basins at the points indicated. To so brim them with slack or slow-falling water as to make them navigable channels from these lakes to the navigable waters of the larger rivers they are intended to feed, and to keep them permanently navigable at seasons of extremest drought and low water, is the task of the engineer.

To minds unaccustomed to the study of the laws that regulate rivers and fix their channels, the idea would at first suggest itself that the effect of diverting these supplying waters of the lakes into the Mississippi would, by increasing so largely its weight and volume, cause it to overflow its low banks, and, in seasons of flood, greatly add to its destructive effects on the levees of its lower basin, and make inundations inevitable and uncontrollable.

But, in point of fact the very reverse of such conclusions would be the result. To clearly apprehend this subject, the character of the bed of the Mississippi must be understood. From the lower rapids of the Mississippi, at Keokuk, Iowa, to the mouth of the river, at the Gulf of Mexico, the bottom is an alluvium of changing sands and delta deposits. To increase the volume of water in the bed of such a river accelerates its current in proportion to the quantity and weight of the increase, and by unchanging laws of hydraulics, deepens its channel. When this increased supply is constant, its effect is to fix a more stable regimen in the bed, and, in time, to regulate into constancy the shifting, shallower currents that have flowed over changing sand bottoms without the weight and volume to deepen through the delta sediment a more fixed channel. From the mouth of the Ohio River, where the supplying waters, proposed to be drawn from all the lakes into the Mississippi, all meet and mingle, the maximum effect of the accelerated current will operate most actively in deepening the channel, and more permanently fixing stability in one unchanging bed, to the mouth of the river at the Gulf.

It cannot be doubted that this acceleration of current and increased weight of water will require but few years to bore a deep channel through the bars at the main mouth, and do more to improve navigation into and from the Gulf than any other plan of engineering those constantly growing obstructions to the commerce of the sea from the great supplying West. These bars, under the existing flow of the river, confining all its flood delta waters between dikes and discharging them into the Gulf, are constantly growing and increasing the difficulties of entering any large-draught vessels into the sea.

Deepening the channel by the acceleration of its current and constancy in its increased weight and volume will facilitate my plan of waste-weirs, that is intended to be made co-extensive with the heaviest floods, and to control them to such natural use as to waste all their waters above mean rise into the low swamps, morasses, and lagoons, until, by cumulative process, their delta deposits shall raise them to high-water level, and convert them from their wastes of desolation and malaria into cotton and sugar-growing lands, inexhaustible in fertility and incalculable in wealth.

In another view, this engineering problem is of supreme national importance. It will form great interior and safe lines of communication eminently necessary for extended military operations in time of war. The last war has taught us the uncertainty of all railway communications for military purposes, and the cost of keeping them open. An enterprising enemy can destroy rail lines as fast as they can be built. What daring raiders cannot do, money can. No one can doubt that Jefferson Davis, had his exchequer been less drained for other more important war purposes, could have subsidized the destruction of every mile of railroad within the loyal States. In any great war with any powerful nation, hired mercenaries would be found along every mile of our principal roads and their destruction would be inevitable. It was the destruction of southern railroads and the opening of the Mississippi River that put an end to the rebellion. They were the main sinews of war and the strength of the South.

But navigable rivers and lakes cannot be destroyed, and they must become our main reliance as an invulnerable military power. The engineering problem I have in this way suggested flashed on my mind as a military necessity thirty-five years ago, when I first saw the extent of our vast lakes, their relation to our great rivers and the extended geography of a country that would be the supplying region in any great and protracted war. These indestructible interior lines of communication are essentially a military need to secure impregnability to a nation peopling this vast extent of continent.

The history of ancient Egypt would furnish an instructive lesson to the engineers of this day. Its engineers had the audacity to seize the waters of the Nile and subject them to the control of man. Thebes and Memphis grew up under the skillful and daring engineering that laid hands on the floods of that strange river and built unmatched pyramids in lands their cunning fertilized, to be the mistress cities of the nations of the East. The inspired genius of Egypt's engineers bridled the floods of the Nile, spread their waters through artificial rivers over vast barren territory, fertilized it by their rich delta deposits, and poured into these cities the wealth that founded an empire matchless in power, civilizing a people whose eloquent memorials of mechanical arts are the wonder of the world and the shame of the nineteenth century.

The Nile still flows on, discharging its fertilizing delta material into the Mediterranean, where its wealth is wasted, threatening, in time, to obstruct the commerce of the East with Europe. The inspiring genius of engineering decayed with the glory of these cities. The scepter of art it once swayed is broken, and no skillful hand has yet so welded its fragments as to venture again to try its trident sway on the uncontrolled floods of this river of myths and traditionary gods. But the history of the daring of these ancient engineers has survived the decay of more than four thousand years. Their imperishable memorials stand round in the pyramids, sphinxes, and granite walls of great reservoirs and artificial rivers, and should startle into energy and activity the slumbering

genius of this age to apply the cunning of their hands on like immortal achievements. Nubia and Lybia, once fertilized by the delta waters of the Nile, now scorch the feet of the Arab with their burning sands, and the traveler sees desolation stand round where the cotton of ancient Egypt was grown for the looms that wrought fabrics of unmatched perfection, and that have enwrapped for four thousand years embalmed kings without decay.

But it should shame us to know that the floods of the Nile are more sudden, and that the fall of the river gives them far greater force than the floods of the Mississippi. Yet they were once subjugated to the skill of Egypt's engineers, and down the bridled waters of the majestic Nile the great granite blocks that were wrought into the pyramids and sphinxes of ancient Egypt were, doubtless, transported. To engineer the floods of the Mississippi is a much easier task. The rain-tables, the water-sheds and basins of its tributaries, are better geographized for engineering, although more vast in their extent. All that is wanting to make them co-operative in effecting one vast hydraulic, controllable, civilizing power, is the genius of daring and enterprise within the scope of possibilities of the thinking, skillful engineer.

Water is the civilizer, power, and wealth of a nation. God has granted it to this continent in fruition of supply and wisdom of distribution, suggestive of empire that shall lead the world, and found the highest civilization attainable by man.

It is not intended in this communication to do more than to outline the principal features of my plan. My convictions of its practicability and economical accomplishment are undoubting. It is national in its purpose, and the magnitude of its importance is incalculable.

It is intended to reclaim and appropriate to use millions of acres of waste lands. It is intended to restore to operation the beneficent law of nature so as to create delta lands. It is intended to open up the navigation of the large interior rivers of Texas and Florida that are now obstructed by bars at their mouths, shutting out their commerce from the sea. It is intended to make the Upper Mississippi, the Illinois, and the Ohio Rivers navigable at all seasons of drought and scarcity of water, and to extend the commerce of the great lakes to the sea by uninterrupted water communication. It is also intended to form imperishable interior military lines of transportation, essential in offensive or defensive war to economy, safety, and impregnability.

As you, Mr. Secretary, are my proper organ of communication with Congress, I transmit this memoir for your careful consideration, and ask, if you see in it practicability and national importance, that you refer it to that body with such remarks as to you may seem befitting.

I am, general, very respectfully, your obedient servant,

B. S. ROBERTS,
Brevet Brigadier General United States Army.

Major General J. M. SCHOFIELD,
Secretary of War.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 16, 1869.

GENERAL: The resolution of the House of Representatives of the 5th instant referred to this office for report, together with the letter of Brevet Brigadier General B. S. Roberts to the Secretary of War, dated December 29, 1868, which contained a printed copy of his memorial on

a plan for reclaiming the waste lands of the Lower Mississippi, are returned herewith.

In reference to those portions of General Roberts's papers which touch upon reclaiming the waste lands of the Lower Mississippi, I submit a copy of a communication made by me in February, 1866, to General Delafield, at his request, which communication I request may accompany General Roberts's papers when transmitted to the House of Representatives.

In respect to the additional paper of General Roberts, (that of the 29th December, 1868,) it seems to me that it is sufficient to state that the idea of connecting the western rivers with the great lakes by a channel without locks, through which there shall be a constant flow of water from the lakes, (and that is the substance of this second paper,) is one that has been frequently enunciated. I do not find in General Roberts's paper any new facts bearing upon its benefits, practicability, or cost. Indeed, he does not seem to know that the degree of practicability of such schemes has been tested on the most feasible line, that of the Chicago and Illinois Rivers.

By referring to the report to these headquarters of Brevet Major General J. H. Wilson, and Mr. William Gooding, on the survey of the Illinois River, transmitted to the House of Representatives in January, 1868, and printed, it will be perceived that the cost of such a channel-way, capable of supplying only 4,500 cubic feet of water per second to the Illinois River, would be more than $30,000,000.

General Roberts anticipates great benefit to the alluvial region of the Mississippi by increasing from the lakes the volume of that river during its floods, because, he says, the bottom is alluvion, and will be dug out deeper the greater the volume. The bottom is not alluvion, but tertiary, or older than the drift, and in this I speak from ascertained facts, not from supposition.

The benefits to be derived from increasing the volume during low water of the upper courses of the western rivers, and the pernicious consequences that would follow upon materially increasing the volume of the Lower Mississippi at the flood, have been so clearly pointed out in "The Physics and Hydraulics of the Mississippi River," &c., and in other reports of engineer officers transmitted to Congress and printed, that it is quite unnecessary to do more than refer to them in this general manner.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Major General J. M. SCHOFIELD,
Secretary of War.

NEW ORLEANS, *February* 22, 1866.

GENERAL: I have received your communication of the 13th instant, inclosing a copy of a "Memoir" of "a plan to reclaim the waste swamps, &c., of the Lower Mississippi Basin, by a new system of diking, so as to use the delta-making material of the water of the river for this purpose," by Brevet Brigadier General B. S. Roberts, United States Army, referred to me for report upon the practicability and expediency of carrying into effect the ideas presented therein, &c.

The plan presented by General Roberts is, in brief, to take from the

Mississippi River at high water "a volume of water equal to, or approximating to an equality with, the surplus of flood-water over the medium flood," and allow it to flow over the alluvial lands bordering the river, and deposit its sediment upon them.

This would, in his opinion, soon elevate those low lands to a considerable extent, and at no very distant day bring them to about the level of the banks of the river, render them cultivable, and the country healthy.

For the facts and figures which I shall use in this communication, I beg leave to refer to the report upon the Mississippi River, prepared by Captain A. A. Humphreys and Lieutenant H. L. Abbot, topographical engineers, and submitted by Captain Humphreys to the Bureau of Topographical Engineers, August 5, 1861.

The knowledge of a few simple facts concerning the region in question, well known to those who live upon the alluvial lands of the Mississippi, would lead one to distrust the feasibility of such a project.

The swamps and shallow lakes of the alluvial region are filled with rain-water long before the river reaches its flood condition, and remain so filled until the river goes down. Any material additions to their volume made by crevasses cause an encroachment upon the cultivated lands, and should the breaks in the levees be extensive and the high water of long continuance, the most serious inundations occur, involving the loss of crops and stock worth millions. The explanation of this is, that the fall of rain upon the alluvial lands is excessive, and the surface so flat that the eye can detect no deviation from a level, careful instrumental measurements being necessary to ascertain the direction as well as amount of the slope that exists. The lakes are shallow, except those along the river, which once formed portions of it and still retain in part its great depth. The facts cited indicate that no large volume of river water can be let in upon the alluvial lands without serious injury to the cultivable portions, the highest parts of the alluvion.

General Roberts proposes to draw off from the river, during the period of high water, and spread upon the alluvial lands all the volume in excess of that of the medium flood. This would bring the surface of the river very nearly to the level of the natural bank. In other words, would restore the conditions existing before any levees were built, and subject the whole alluvial region to overflow. Perhaps he may dissent from this exhibit of his proposition, but he will not object to my using, in a discussion of the project, the quantity of sedimentary matter contained in the volume of river water indicated. Let us see, then, how much earthy matter that volume would spread upon the alluvial lands. The area of those lands is—

	Square miles.
The St. Francis bottom	6,300
The Yazoo bottom	6,800
The Tensas and Macon bottom	4,000
The alluvial lands below the mouth of Red River	12,300
Total	29,400

I will take the most favorable case for the project, the great flood year of 1858. The river during that year was less than one hundred and thirty days above the natural bank. Let us assume it to have been one hundred and thirty days. The surplus volume discharged by it

during that time, over and above the volume discharged by the river when just bank full, was 1,200,000,000,000 cubic feet.

Now, had this quantity escaped from the river into the alluvial lands during the period of high water of 1858, it would have flooded the whole alluvial region, cultivated as well as uncultivated, from Cairo to the Gulf, during the entire period of one hundred and thirty days.

For the quantity of earthy matter held in suspension by the river water, I will use the largest proportion found in the investigations made upon the Mississippi River under my direction. That proportion is $\frac{1}{1200}$ by volume. That is, for every 1,200 cubic feet of water, there was one cubic foot of earth. This is double the amount of sedimentary matter carried by the river water during the mean flood period. The proportion of $\frac{1}{1200}$ would give for the volume of water just noted 1,000,000,000 cubic feet of earth.

I should explain here that when there were no levees the water thrown off by the river into the St. Francis bottom returned to the river again by the returning bayous and the St. Francis River, having deposited its sedimentary matter upon the bottom lands. It thus protracted the duration of the flood.

The water similarly thrown off into the Yazoo bottom returned to the river by the Yazoo River. The same is to be observed of the Tensas bottom, the water returning to the Mississippi by Red River.

Again, in order to make the most favorable case possible for General Roberts's project, I will suppose that the whole volume of water necessary to bring the river within its banks in the flood of 1858 entered each bottom land in succession, that is, the bottom lands of the St. Francis, the Yazoo, and the Tensas.

We have seen that that volume of water carried in suspension 1,000,000,000 cubic feet of earth. That bulk, when spread upon an area of 6,000 square miles, (the area of the St. Francis bottom,) would have a thickness of $\frac{1}{150}$ of a foot. At this rate it would require twelve years to make a deposit one inch thick upon the St. Francis bottom.

But the time that the flood of 1858 was above the natural bank of the river was more than double that of the average floods, and we should have, for an average effect of flooding yearly all the St. Francis alluvion, less than one inch of deposit for twenty-four years of overflow. The mean difference of level of that swamp and the bank of the river is ten feet. To bring up the swamp to the level of the river bank would require more than two thousand eight hundred and eighty years. If the smaller quantity of sedimentary matter were used, the number of years would be about doubled.

If the sedimentary matter could be concentrated instead of being spread over the whole bottom, the depth of deposit would of course be increased. But the shape of the country is not adapted to this process. Moreover, the project of General Roberts comprises the whole area of the alluvion.

Here let me remark, that the project is not new to me; it is probably as old as the levee system, and is a fruitful subject of discussion with persons living on the alluvion, especially those who have noticed the deposits made by crevasse water at the edge of the swamp in the immediate vicinity of the crevasse, when the break in the levee was large and the high water continued. A notable example of it was given by the great Bonnet Carré crevasse of 1850, which, though only six miles from Lake Pontchartrain, and having therefore comparatively free flow to the Gulf, flooded an extensive district and destroyed a large amount of property. Such notable deposits are made only when the crevasse is

so large that immense damage to the plantations on the alluvion is incurred.

It seems to me unnecessary to illustrate the subject further, or apply figures to the other bottom lands. So long as there are vast districts of the higher portions of the alluvial land along the Mississippi River that are unoccupied, and will remain so until the river is effectually leveed, it appears to me unnecessary to set investigations on foot to ascertain whether some limited localities of the lower portions of the alluvion can be raised by letting in upon it the turbid river water, especially as the features of the country are not adapted to the economical use of such processes.

The figures exhibited show that such a process upon a large scale is impracticable. The only practicable mode of reclaiming the swamp lands is to levee the river banks securely, and as cultivation extends inward, to establish a proper system of drainage.

The second view presented by General Roberts is, that by spreading a portion of the sedimentary matter of the river upon the swamp lands, there will be less of it deposited in the Gulf at the mouths of the river. In his opinion the bars will not then extend so rapidly into the Gulf as now, and, as a consequence, the surface of the river in its lower course, or near the sea, will not be raised as rapidly as it is now, (the rise of surface due to the extension of the mouth of the river into the Gulf,) and the height of the levees on the lower plantations will not have to be increased as frequently as now. Further, he is of opinion that there will then be a greater depth of water upon the bars at the mouth of the river than there is now.

Respecting the increase of height to be given to the levees in the lower course of the river, owing to the progress of the mouths into the Gulf, I beg leave to refer to pages 435 and 436, "report upon the Mississippi River," &c., where it is shown that it will require an extension of the mouths of the river twenty-five miles into the Gulf to raise the surface of the river one foot at Fort St. Philip, and that according to the present rate of progress, five centuries will elapse before the river accomplishes that extension.

Owing to the great depth of the Gulf, where the mouths of the river now lie, the rate of progress into the Gulf will be slower in future than it has been in past days.

As to increasing the depth of water upon the bars by reducing the quantity of sedimentary matter brought to the Gulf, I beg leave to remark that the depth upon those bars depends upon the quantities of water discharged over them, and not upon the quantity of supsended sedimentary matter brought to the Gulf by the river water. Further, the bars are not formed by the deposit of the sedimentary matter of the river, but by the deposit of the earthy matter pushed or moved along the bottom of the river. Hence, a reduction of the sedimentary matter of the river will not diminish the magnitude nor affect the form of the bars.

Should any further information or views concerning the bars be desired, reference can be made to the last chapter of the report already mentioned.

Having thus shown the impracticability of attaining the ends proposed by General Roberts, I trust I may be excused from presenting a view of the cost necessary to carry out his plans.

The popular impression that the floods of the Nile are allowed to spread upon its alluvion, has been sometimes referred to by persons ignorant

of the totally different conditions of the two rivers, as a reason for allowing the floods of the Mississippi to flow over its alluvion.

The floods of the Nile are regular in their recurrence, the greatest height being attained usually in September; the planting and sowing season follows the subsidence of the flood. Egypt is in the rainless region, and the overflow of the Nile fills, periodically, all the reservoirs, tanks, and canals from which the fields are irrigated, and supplies of water for every purpose are furnished. The best authorities state that its floods are not permitted to spread over its banks.

The floods of the Mississippi are irregular in their period, height, and duration, but on the average may be said to reach their height about the 1st of April. The river then remains in high-water condition, falling and rising until about the middle of July; and there are no means of predicting whether it may not be above the natural bank during all that time. There are, indeed, two maximum high-water points reached each year, the one about the 1st of April, the other about the 1st of June.

The planting and sowing season on the Mississippi begins just as the river reaches its height, and the high-water condition so late into the summer that no extensive crops can be gathered from any planting done after the river has begun to sink it to its low-water condition. Wherever its floods spread, thick-growing willow and cottonwood spring up, destroying the cotton and sugar plants, and requiring years for their eradication.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Major General Volunteers.

Brig. and Bvt. Maj. Gen. RICHARD DELAFIELD,
Chief of Corps Engineers U. S. A.

M 4.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 19, 1869.

GENERAL: In reply to the communication of the chairman of the Committee on Commerce, of the Senate, dated January 26, 1869, asking for information "relative to the probable cost of building and repairing the levees in the States of Louisiana, Mississippi, and Arkansas, as designated in Senate bill, No. 795, of the present session," I transmit a report upon the subject by Brevet Brigadier General H. L. Abbot, corps of engineers, to whom, on account of his connection with the surveys and investigations made in 1857–'61, and with later examinations of those levees in 1865–'66, and of his thorough knowledge of the subject, this matter was referred.

The report treats, first, of the repairs required to bring the existing breaks in the levees to the dimensions now adopted by the State authorities; second, of giving increased thickness to the present levees, without increasing their height; and third, of the increased height and thickness to be given to the levees, in order to protect the alluvion of those States against overflow when the whole flood-volume of the Mississippi is confined within its banks, by a levee system perfected from the head of the alluvial region to the Gulf of Mexico.

The estimates of cost for, first, repairing the existing breaks; second, for increasing the thickness of the existing levees with the present height;

and third, for perfecting levees to a height sufficient to guard against all probable contingencies, are summed up by him as follows:

	For repairing existing breaks.	For perfecting existing levees to present height.	For perfecting existing levees to proper height.
LOUISIANA.			
Below Red River, (both banks)	$600,000	$1,730,000	$4,600,000
Above Red River, (right bank)	200,000	800,000	8,420,000
To exclude water escaping above boundary	250,000	250,000	2,000,000
Total	1,050,000	2,780,000	15,020,000
MISSISSIPPI.			
Yazoo grant	1,500,000	1,500,000	4,150,000
ARKANSAS.			
Louisiana to Arkansas River	700,000	960,000	4,700,000
White River to Helena	150,000	350,000	2,000,000
St. Francis bottom lands	1,000,000	1,600,000	12,360,000
Total	1,850,000	2,910,000	19,060,000
Grand total for the three States	4,150,000	6,940,000	36,230,000

NOTE.—The third item, under the State of Louisiana, is to "exclude water escaping above the boundary;" and the amount being included in the estimates under the head of Arkansas, it is not carried out in the "grand total for the three States."

I fully concur in the views of General Abbot.

As this report is a continuation of the subject treated in the report of 1861, which was recently printed by Congress, and as it is a subject of great importance, I would respectfully recommend that this also may be printed by Congress.

Very respectfully, your obedient servant,

A. A HUMPHREYS,
Brigadier General of Engineers, Commanding.

Bvt. Maj. Gen. J. M. SCHOFIELD,
Secretary of War.

Report on repairing and perfecting the levees of the States of Louisiana, Mississippi, and Arkansas, including an analysis of the floods of 1862, 1865, *and* 1867, *with an appendix containing an abstract of facts collected respecting the principal tributaries of the Mississippi River during these great inundations. Submitted to Major General A. A. Humphreys, Chief of Engineers, by Brevet Brigadier General Henry L. Abbot, major corps of engineers.*

WILLETT'S POINT, NEW YORK HARBOR,
February 16, 1869.

GENERAL: In accordance with instructions from Headquarters Corps of Engineers, dated December 23, 1868, I have the honor to submit the following report upon the repairs required to bring the existing breaks in the levees of Louisiana, Mississippi, and Arkansas, to the grade line now adopted by the State authorities; and also upon the more general question of protecting those States against overflow when the whole flood volume of the Mississippi is confined within its banks, by a levee system perfected from the head of the alluvial region, to the mouth. These two questions are quite distinct, and they will be considered separately.

REPAIRS OF EXISTING BREAKS.

The condition of the levees of the Mississippi, in the preceding January, is detailed in your report to the Secretary of War, dated May 31, 1866. Respecting the changes in their condition, since that date, the information in my possession is of a general character, being confined to the annual report of the board of levee commissioners of Louisiana, dated January 31, 1867; to a letter from Mr. J. A. Parker, recently chief engineer, second division, Louisiana levees, detailing their condition in that State, above Red River Landing, in May, 1867; to a letter from Mr. Minor Meriweather, chief engineer of the southern levee district of Mississippi, giving the condition, in April, 1867, of the levees under his charge, and, in general, of the other levees of that State; to certain vague information respecting the levees of Arkansas; and, lastly, to the general facts, that the high water of the spring of 1866, although not properly a great flood, did very considerable damage to the unfinished works then in progress, reducing them to nearly as bad a condition as they were in before the work of repair was undertaken, in the autumn of 1865; that the high water of 1867 was a great flood, causing immense destruction throughout the alluvial region, and that the high water of 1868 did not rise above the ordinary spring stage of the river, doing only trifling injury. It is, therefore, evident that the following exhibit of the present condition of the Mississippi levees, although sufficiently exact for general purposes, can only be considered an approximation to the truth.

The State of Louisiana alone seems to have made any determined effort to close the breaks in the levees. Between November 14, 1865, and January 31, 1867, there was expended, under the direction of the board of levee commissioners, $2,061,516 13 in making 4,674,414 cubic yards of embankment; leaving an estimated amount of $46,795 still required to complete the repairs. The amounts paid for superintendence, for closing crevasses in 1866, for negotiating bonds, &c., &c., amounting to over $600,000, are not included in this sum. The early flood of 1867 caused immense destruction throughout the State, notwithstanding this outlay.

The State of Louisiana may be conveniently divided into three great levee districts—the right bank from the northern boundary to Red River, the right bank below Red River, and the left bank below Baton Rouge.

Of these, the first is subject to peculiar difficulties, arising from the fact that the alluvial bottom lands extend above the State line into Arkansas, where they become too narrow to offer the greatest inducements for their owners to reclaim them, especially, as in the northern part danger is to be apprehended from overflow, both from the Mississippi and from the Arkansas. This unfortunate geographical position has always caused the planters of the Tensas bottom lands to suffer from overflow due to defects in levees not under their own control.

The most obvious means of protecting this part of Louisiana is a guard levee; which, starting from the Mississippi near the boundary line, shall be extended westward, diverging a little toward the south to follow a low ridge, until high land is reached. The length of the route is 22,800 feet, and the mean depth of overflow in the greatest floods, 7.1 feet; the latter corresponding to a horizontal line drawn from the high-water mark of 1828 on the bank of the Mississippi.

Adopting the present grade line of the State of Louisiana, these figures call for a ten-foot levee, containing about 300,000 cubic yards of embankment, and costing about $120,000.

This is, no doubt, the most sure, and probably the most economical method of obtaining temporary security against overflow from the State of Arkansas.

There are, however, two serious objections to the project: first, such a levee would close Bayou Maçon, the natural drain of a large district of swamp lands in Chicot County, Arkansas. This would entail the additional expense of providing a new channel for its rain-water discharge, at a cost which can only be determined by detailed surveys. Second, in flood seasons, such a levee would form, from any crevasse water escaping from the Mississippi, in Chicot County, Arkansas, an immense lake, which would effectually overflow the plantations in the vicinity from backwater. The project would, therefore, be vigorously opposed by the land owners in that district, and there would be danger of the levee being designedly cut. A compromise might, perhaps, be made by leaving Bayou Maçon open, and extending levees down its banks to a point southwest of Providence, where the natural drains become so large as to permit the passage of about 100,000 cubic feet per second, without injury to the bordering plantations; but, as will soon be explained, the ultimate requirements of a perfected levee system will make this scheme too dangerous to be adopted without careful surveys and borings.

Another method of protecting Northern Louisiana against overflow from Arkansas, is to extend the main Mississippi levees up the bank to Gaines's Landing, or perhaps only to the vicinity of Columbia, near which a part of the overflow from above is diverted into bayou Bœuf, thus partially relieving bayou Maçon.

It is to be regretted that the report of a recent survey, (1866 or 1867,) made in Chicot County, Arkansas, under the direction of the levee board of Louisiana, to throw light upon this problem, is not at hand. In the winter of 1865–'66, these levees were in a very bad condition, and it is believed that they are even worse at present.

There were then seven breaks between the Louisiana line and Columbia, requiring about 390,000 cubic yards of embankment, costing about $156,000; and four breaks between Columbia and Gaines's Landing, requiring about 350,000 cubic yards of embankment, costing about $140,000. The levees still standing were much worn in many places, and the river was badly eroding its bank in the bend above Columbia. It may be safely assumed, therefore, that the present cost of repairing the levees to the existing grade from the State line to Columbia will not fall below $200,000, and thence to Gaines's Landing not below $200,000.

Whatever project is adopted, we may, therefore, be sure that $250,000 is a very moderate estimate of the outlay which is absolutely essential to prevent crevasse waters from flowing through Chicot County, Arkansas, into Northern Louisiana, even supposing that the present height of the levees is sufficient.

From the northern boundary of Louisiana to the mouth of Red River, it would appear that a decided improvement was made between January, 1866, and May, 1867; for, on the latter date, Mr. J. A. Porter, chief engineer, second division Louisiana levees, furnished the following list of crevasses, which shows that the new levees, at several bad breaks, named in your report to the Secretary of War, had resisted the flood. Mr. Porter, however, adds that his estimates of the extent of the breaks is not based upon "that instrumental data which is alone accurate and reliable."

No. 1. Bass levee, three miles below Providence. Break occurred in

upper wing connecting old and new levee; width, one thousand feet; mean depth of water, nine feet.

No. 2. Hawes Harris's place, on boundary line between Carroll and Madison parishes. Break occurred in a temporary levee, the main line, as located, not having been worked upon; width, three-fourths of a mile; mean depth of water, six feet.

No. 3. Towne's place, at lower mouth of General Grant's Canal, four miles below Vicksburg. Break occurred in an old levee; width, one thousand feet; depth of water, six feet.

No. 4. Buckner's place, in upper part of Tensas Parish. Break in an old levee; width, four hundred feet; depth of water, three feet.

No. 5. Lower end of Point Pleasant levee, just above the Davis cut-off. Break in new levee, supposed to have been cut; width, seven hundred feet; depth of water, five feet.

No. 6. Brownler's, about five miles below Grand Gulf. Break caused by a cave, partly in old and partly in new levee; width, six hundred feet; depth of water, two and a half feet.

No. 7. Bondurant's, opposite Bruinsburg. Break caused by a cave in new levee; width, three hundred feet; depth of water, three feet.

No. 8. J. M. Gillespie's, one mile above St. Joseph. Break in old levee; width, five hundred feet; depth of water, five feet.

No. 9. Kempe's levee, about six miles below Rodney. Break occurred in new levee; width, one thousand five hundred feet; depth of water, nine feet.

No. 10. Surget's place, near Lake Concordia, known as the Marengo levee. Break caused by the giving way of the levee in an old bayou; width, one thousand feet; depth of water, eight feet, (in bayou, thirteen feet.)

A comparison of certain of these breaks with their condition as given in your report to the Secretary of War, indicates that Mr. Porter's "depth of water" refers to the surface flowing through the opening, and that this is about three feet below the top of the levees in the vicinity. Upon this supposition, if the breaks could be repaired upon straight lines connecting their ends, there would be required about 134,000 cubic yards of embankment. But such a location cannot be given to the new levees, which must, in several of the crevasses, take the form of extensive hoops, in order to be out of danger from caving bends.

In January, 1866, the embankments required for repairs in this district, (above Red River,) omitting what was probably completed before the high water of that year, exceeded 800,000 cubic yards. Although several of the worst breaks had been permanently closed, some new ones had been made, and it may safely be assumed that 500,000 cubic yards of embankment, costing about $200,000, was required at the date of Mr. Porter's letter, to put the levees in a state of ordinary repair upon their present grade. Probably no less sum is required now.

Below the mouth of Red River, I have no information subsequent to the date of the report of the levee commissioners, which was presented before the flood of 1867. This states that the levees were either finished or in such a state of progress as to be considered secure on January 4, 1867, except the Chinn, and Robertson, Grand and Morganza levees; and that it was anticipated that these would be completed by February 1. This was, however, hardly as favorable an exhibit as for the district above Red River, in which we have seen that the flood committed great ravages. In January, 1866, there were fifty-nine breaks below the mouth of Red River, requiring 1,564,000 cubic yards of embankment. Assuming the same probable ratio of destruction below as above, the flood of 1867

should have left in this district crevasses requiring 1,000,000 cubic yards of embankment, at a cost of $400,000. Subsequent deterioration has probably raised this sum to $600,000. This estimate is hardly better than a guess; but, in the absence of authentic information, it will be adopted as perhaps sufficient for the general purposes of this report.

The total cost of repairing existing breaks in Louisiana, not including water entering through Chicot County, Arkansas, is, then, $800,000. In 1866, this amount was estimated at $1,200,000.

The State of Mississippi is fortunate in having her great district of alluvial lands entirely under her own control, exposed to danger of overflow from no other State. It is situated, however, in precisely that part of the valley where the difficulty of restraining the floods is greatest. Her system of levee organization, adopted 1858, was far in advance of that in other States; and her levees would doubtless now be the best upon the river, had not the war caused them to be neglected, and in part destroyed.

My information concerning the breaks in this State is more exact than for any other—in fact, is partly official; being for the district comprised between Sunflower Landing, in Coahoma County, and the Vicksburg Bluffs, supplied by Mr. Minor Meriweather, chief engineer; above it, is from Mr. William Henson, civil engineer, residing at Friar's Point. Both letters bear date in 1867, after the flood had begun to recede. In connection with your report of 1866, they render it possible to make reliable estimates for this region, which comprises the Yazoo bottom land.

Beginning at the north, there were in 1866, in De Soto County, about 4.5 miles of breaks, contents 150,000 cubic yards; in Tunica County, 8.5 miles of breaks, contents, 460,000 cubic yards; in Coahoma County, above Hushpuckana, nine breaks, contents, 270,000 cubic yards; making, on the Yazoo front, above Sunflower Landing, a total of 880,000 cubic yards of embankment necessary in 1866. No repairs have been made since the date of these surveys, and in the flood of 1867, "numerous minor breaks" were formed, "nearly all small." Allowing for the wear of the exposed ends of the levees, and for these new breaks, 1,000,000 cubic yards of embankment, costing $400,000, is a fair estimate of the requirements for this district. The only other break in Coahoma County is Hushpuckana crevasse. About five miles of new levee were constructed in 1866, upon the permanent location, to close this break, one of the most troublesome upon the river; but it broke in the flood of 1867. There are three nearly equally costly locations for the new levee; contents, about 700,000 cubic yards. In Bolivar County, there are three bad breaks, Pride's, Niblet's and Easten's, which required, in 1867, according to Mr. Meriweather, 11.65 miles of levee to close them on the permanent location. The contents would probably be about 500,000 cubic yards. In Washington County, there is only one bad break, the Miller Bend crevasse, contents, 150,000 cubic yards. In Issaquena County, two important points only required repair in 1867, viz: Wade's and Christmas's; length of new levee necessary, 3.5 miles; contents, probably about 200,000 cubic yards. This completes the levees of the State of Mississippi. The total requirements to close existing breaks are 2,550,000 cubic yards, at a cost of about $1,020,000. Repairs in caving bends, which cannot long be deferred, will raise this amount to fully $1,500,000.

The State of Arkansas is naturally divided into three level districts; that extending from the Missouri line to Helena; that extending from

Helena to the mouth of White River; and that extending from the Arkansas River to the Louisiana boundary.

The district extending from the northern boundary to Helena is the most unfortunate, in its geographical location, of any upon the river, being entirely dependent for its security upon the perfection of the levees of Missouri. Water leaving the Mississippi, between Cape Girardeau and Commerce Bluffs, or between New Madrid and the Arkansas boundary, pours through the back country and returns to the Mississippi, in Arkansas, through Mill Bayou, opposite Island 30; Wappenoky Bayou, near Island 40; a bayou near Island 46, or, generally, over the banks below Council Bend. Unless such water can be kept in the channel, the levees are attacked from the rear and washed into the river at and near the points indicated. It is, therefore, evident that no general system of protection can be carried into effect for Arkansas, without including, as an essential part of the project, the perfection of the levees in the two districts of Missouri above named. Added to this difficulty is the one even greater, that the river erodes its banks much more rapidly in this part of its course than nearer its mouth, owing to the more frequent and violent oscillations of its surface. Hence the construction of a levee system upon the immediate banks of the stream would be highly injudicious, so far as the protection of the back country is concerned; moderate levees, for local interests, might probably repay investment, as the recurrence of very great floods is rare. In a later portion of this report, when treating of a perfected levee system, these facts will be again considered; here, they are only mentioned in order to explain the necessity of including a part of Missouri in the estimates for repairing existing breaks in the Arkansas levees.

The inlet between Cape Girardeau and Commerce is small, and may be neglected in so very partial a treatment of the problem as that now under consideration.

From New Madrid to the Arkansas boundary the levees are in a tolerably good condition, and in 1866 there was a balance of the original levee fund, donated by the general government to the State, still on hand. The distance by the levee route is about fifty miles; the needful repairs would probably be covered by $150,000.

From the boundary to Memphis there were, in 1866, ten breaks, generally not long, but often deep. About 700,000 cubic yards of embankment were required, probably at a cost of fifty cents per yard, amounting to a total of $350,000. As the country had then recently assessed a tax for levee purposes, it is probable that further deterioration has been prevented.

Below Memphis, the levees, in 1866, were in a very bad condition, constructed in the first instance too near the river, which in this vicinity is rapidly eroding its banks, (about 1.5 mile in forty years in Council Bend,) subject in the lower third to overflow from the rear; and, above all, having been neglected for several years, the levee might safely be considered as worthless. To repair it would be more expensive than to build a new levee on a proper location, removed from caving bends. The total distance is about seventy miles, and the cost of repairs (to old grade) would not be less than $500,000.

In fine, then, the repair of existing breaks on the St. Francis front, necessary to bring the levees, upon which depends the safety of the Arkansas lands, into as good condition as the portions still remaining uninjured, would involve an expenditure of about $1,000,000. When completed, these repairs would have so temporary a value that in ten

years, unless an immense annual outlay were made, the country would probably be as much exposed to overflow as at present.

The Arkansas levee district, included between Helena and White Rivers, is more fortunate than that just considered, in being perfectly protected from overflow from above by the Helena hills. It is, however, very small in extent. From Helena to Oldtown Ridge there were, in 1866, five breaks, contents 148,000 cubic yards, costing about $59,000 for repairs. From Oldtown Ridge to Carson's Landing, near Islands 67 and 68, there were then several breaks, the worst being at the Lima place—total contents about 150,000 cubic yards, requiring about $60,000. Thence to Laconia, the levees were good, (distance fifteen miles.) At Laconia the planters had repaired the State levee to Bob's Bayou, which enters the Mississippi two miles below Island 71, a distance of seven miles, and had connected these termini by a rear levee eleven miles long, to keep out the overflow from White River, thus inclosing 15,000 acres of good land. The Laconia circuit broke in the upper part in 1867, and had to be cut below to let out the water. From Bob's Bayou to Napoleon no levees ever existed. Probably the cost of repairs in this entire district would not exceed $150,000; but its protection is strictly a local matter.

The third Arkansas district, or rather that part of it lying below Gaines's Landing, has already been considered in discussing the protection of Northern Louisiana. Above Gaines's Landing, to Desha County line, the levee is reported good. Thence to Napoleon it is practically gone. To protect this region from floods in Arkansas River, and from Mississippi back-water in that stream, levees have been extended up the river from near Napoleon to a point forty-five miles below Little Rock, chiefly on the southern bank. The upper part of these levees is reported good, but several breaks are named, particularly at four, at ten, and at fifteen miles above Napoleon, and near Heckatoo plantation. To close the breaks in both rivers sufficiently to protect the region above Gaines's Landing from overflow, (present grade,) would probably involve an outlay of $300,000, making the total cost of repairing breaks in this third levee district of the State of Arkansas about $700,000.

To close the breaks necessary to protect the entire State would then call for an expenditure of $1,850,000.

In fine, then, to close the breaks now existing in the Mississippi levees, would cost as follows:

State of Louisiana	$1,050,000
State of Mississippi	1,500,000
State of Arkansas	1,850,000

It should be remembered, however, that in these estimates the cost of excluding crevasse water, entering Louisiana through Chicot County, Arkansas, ($250,000,) is contained twice, once for Arkansas and once for Louisiana, and that the outlay required for Arkansas also gives protection to a part of Missouri.

It should also be borne in mind that this money is required to simply replace the levee system of the Mississippi where it has already been when most complete. This is far below what the real security of the region demands, and the only justification for such an expenditure would be found in the fact that it would enable planters to make crops in ordinary seasons, well knowing that at any recurrence of great floods, which happens usually about once in three or four years, extensive inundations would be sure to occur. In the suffering and reduced condition of the region at present, some such temporary and partial relief might enable

the planters to obtain enough funds and credit to save their estates from ruin, and thus prepare, eventually, for building the more extensive levees which security demands.

A PERFECTED LEVEE SYSTEM.

The investigations and surveys conducted by yourself between the years 1850 and 1861, and fully elaborated in the report upon the physics and hydraulics of the Mississippi, which constitutes professional papers No. 13 of the corps of engineers, have demonstrated that the best, and, indeed, the only feasible method of protecting the alluvial region from overflow, is that of a levee system in which the dimensions of the embankment are computed to restrain the maximum flood discharge of the river when confined to the channel from Cape Girardeau to the mouth. In that report the whole subject is thoroughly discussed, and the dimensions of the levees in all parts of the region are computed in detail from the very elaborate and exact data obtained by actual measurement in the flood of 1858. That flood was adopted as the standard, because a close comparative analysis of all other recorded floods, including that of 1859, proved that in no other would the maximum discharge have been in excess of what would have occurred in that flood had the levees been able to restrain the river to its bed. Hence, at the date of that report (1861) the probable difficulty and cost of a perfected system which should give to the plantations upon the banks of the Mississippi the same security that is enjoyed by the fields of Holland, was accurately known. The only point which demanded further investigation was, whether the flood of 1858 had been correctly assumed as a standard, a point which time alone could certainly determine.

Since 1859, there have been but three great flood years—1862, 1865, and 1867; the others belong to the class of ordinary high waters, in which the projected levees would have largely exceeded the requirements of the maximum volume. To decide, therefore, at the present time upon the proper dimensions of levees for the Mississippi, we have only to compare carefully those three great floods with that of 1858, to ascertain whether or not the water-marks and recorded facts indicate a maximum discharge at the head of the alluvial region, or just below the mouths of any of the lower tributaries, in excess of that which would have occurred in 1858, had all the water been confined to the channel from Cape Girardeau to the Gulf. If this question be decided in the negative, the flood of 1858 remains a safe standard; if in the affirmative, the estimates in the physics and hydraulics of the Mississippi must be modified to allow for the increased volume to be apprehended.

The first point, then, for attention is, the extent of the information which has been preserved respecting the three great floods in question.

When acting as your assistant, upon the examination of the levees, in the winter of 1865–'66, I made every effort to collect all possible facts respecting the floods of 1862 and 1865. Sufficient high-water marks were found to indicate, with a good deal of precision, the level attained by each of these floods, as compared with that of 1858, throughout the alluvial region. Through the kindness of Mr. Aug. V. Taylor, at Cairo, and of Mr. G. W. R. Bayley, at New Orleans, daily records of the stand of the river at those points in 1865 were received. Some meagre information respecting the condition of the different tributaries during the two floods was also secured; but the war had distracted attention from river phenomena, and the lapse of time had rendered it impossible to collect as full data as could be desired, especially for the flood of 1862.

Before the flood of 1867 had subsided, instructions were issued from the headquarters of the Corps of Engineers to Brevet Brigadier General McAlester, at New Orleans, to Brevet Colonel Merrill, at St. Louis, to Brevet Major Burroughs, at Nashville, and to Mr. W. Milnor Roberts, superintending engineer of Ohio River improvements, to collect all possible data respecting the overflow. Circular letters were accordingly at once addressed to the different civil and military authorities, requesting facts. Many valuable letters were received in reply. This material accompanied your instructions directing me to prepare this report, and upon it, and a few other data received from Mr. S. Staats Taylor, at Cairo, and from Colonel Merrill, at St. Louis, the following analysis of this flood is based.

Before proceeding to the detailed discussion of the three floods, the following table is presented to exhibit their relative high-water marks, as compared with the floods of 1858 and 1859. It is properly a continuation of the flood-table on page 170 of Physics and Hydraulics of the Mississippi; but the flood level of 1862 has necessarily been adopted as the plane of reference, instead of that of 1858. The sign + denotes that the flood in question exceeded the height attained in 1862, and the sign — that it fell short of that height. The numbers following the signs denote the difference in height attained in the two floods, expressed in feet. In comparing the high-water levels in these different floods, the fact must be borne in mind that four cut-offs have occurred during the period, viz: the American Bend cut-off, on April 15, 1858; the Napoleon cut-off, on April 11, 1863; the Terrapin Neck cut-off, early in March, 1866; and the Davis cut-off, at Palmyra Bend, on February 10, 1867. Their relative positions are indicated in the table.

Comparative heights of recent floods.

Locality.	1862.	1858.		1859.		1865.		1867.	
	Date.	Diff.	Date.	Diff.	Date.	Diff.	Date.	Diff.	Date.
		Feet.		*Feet.*		*Feet.*		*Feet.*	
St. Louis	Apr. 26	+5.7	June 15	......	......	—6.3 —4.6	Apr. 1 July 28	—6.9 —3.0	Feb. 21 May —
Cairo, Ill	May 2	—1.2	June 21,22	—4.3	May 7	—2.8	Mar. 17,18	—0.3	Mar. 21
New Madrid	......	......	......	......	......	......	......	—0.7	Mar. 25,27
Five miles above Osceola	May 6	+0.2	June 17,23	......	......	......	......	—0.1	Mar. 23,24
Osceola	......	......	......	......	......	......	......	—0.3	Apr. 1
Memphis	......	—0.5	June 23	—0.6	May 12, 13	—1.1	......	—0.5	Mar. 26
Head of Cat Island	......	—0.7	......	......	......	—0.9	......	......	......
Foot of Cat Island	......	—0.7	......	—1.0	......	—1.0	......	......	......
Head of Walnut	......	—1.1	......	—3.1	......	—1.5	......	......	......
Helena	......	—1.8	July 2, 6	—2.8	Mar. 22	—2.0	......	—0.6	Apr. 1
Friar's Point	......	—1.4	......	—2.1	......	—1.4	......	—0.0	Apr. 1,3
Wilkinson's Landing, Island 63.	......	—0.9	......	—0.8	......	—0.9	......	......	......
Sunflower Landing, Island 66.	......	—0.8	......	—0.5	......	—0.5	......	—0.4	Mar. 15
Concordia	......	......	......	......	......	......	......	—0.6	Mar. 29
One mile above White River.	......	......	......	......	......	......	......	—1.7	Mar. 30
Three miles below White River.	......	......	......	......	......	......	......	—0.9	Mar. 30
Out-off, *April* 11, 1863.									
Six miles above Beulah, (in old river, made by cut-off, April 11, 1863.)	May 4	—1.4	Apr. 1 July 8	—1.4	Mar. 22	—1.3	Apr. 12	—1.8	Mar. 14
Napoleon	Apr. 20	—2.1	Apr. 6,7	—1.8	Mar. —	—0.3	......	—0.8	Apr. 3
Bolivar Bend, Island 76	......	......	......	......	......	—0.7	......	......	......
Choctaw Bend, Island 79	......	......	......	......	......	—0.5	......	—0.8	Mar. 20
Greenville, Island 83	......	+1.4	......	......	......	......	......	—2.9	Apr. 1

Comparative heights of recent floods—Continued.

Locality.	1862.	1858.		1859.		1865.		1867.	
	Date.	Diff.	Date.	Diff.	Date.	Diff.	Date.	Diff.	Date.
Cut-off, April 15 1858.		*Feet.*		*Feet.*		*Feet.*		*Feet.*	
Bunche's Bend								−2.1	
Wade's (Island 93)								−1.5	Apr. 8
Providence			Apr. 8		Apr. 25			−1.8	
Cut-off, March, 1866.									
Mouth of Yazoo								−0.0	
Vicksburg	Apr. 27	−2.2	June 26,27	−0.9	Apr. 21, 30	−2.7		−2.3	
Island 104, (Diamond)								−1.0	
Cut-off, February 10, 1867.									
Below Davis's cut-off								+1.0	
Hard Times								+1.0	
Vidalia			June —		May 2			+0.2	
Red River Landing			July 13			−0.0			
Duvall's (Island 124)						−3.5			
Carrollton		−0.8	May 10, 12	−0.4	May 6				
Algiers		−0.7		−0.5					

Flood of 1867.—As the records of this flood are more complete than of either of the others, it will be considered first.

In some respects its origin was peculiar. The winter of 1866–'67 was marked throughout the southern portion of the Ohio Valley by an unusual down-fall of snow and rain; while in the region drained by the Upper Mississippi and Lower Missouri the season was remarkably dry. A sudden thaw with warm rains in February caused moderate floods in the Alleghany and Monongahela rivers, and in the smaller tributaries of the Ohio, leading near the main stream; and a great flood, second only to the flood of 1858, in the Wabash. The combined effects of those freshets was to cause a very sudden rise in the Ohio, which culminated at Louisville on February 22, where it was only eight feet below the high water of 1832; and at Caseyville, below the mouth of the Wabash, on March 1, where it was half a foot above the high water of 1832, the greatest of the recorded floods at that locality.

The same climatic influences extended over the valleys of the Illinois River and other southern tributaries of the Upper Mississippi, producing a moderate freshet in the Mississippi at St. Louis. The rise there began on February 13, the river being 25.5 feet below the city directrix; it culminated on February 21, at 9.3 feet below this bench; after remaining four days sensibly at a stand, the river gradually subsided, until, on March 21, it was 21 feet below the directrix. The freshet at St. Louis was by no means a large one, being 16.9 feet below the high water of 1844, and 12.6 feet below that of 1858; still, it is evident that it almost exactly combined at Cairo with the February rise in the Ohio, and thus did its maximum of injury to the alluvial regions. The downfall at St. Louis was 2.3 inches in January, 4.8 inches in February, and 2.4 inches in March, showing a slight indication of the great February rains, but none whatever of those in March.

Such was the condition of the rivers, when, in March, a wide-spread series of furious rain-storms occurred. The belt containing them extended from the headwaters of the Washita and White Rivers of Arkansas, eastward across the States of Arkansas, Missouri, Kentucky, Tennessee, Western North Carolina, and Western Virginia; but it was in the mountain region, where heads the Tennessee River, that the greatest

deluge occurred. The downfall here was entirely beyond precedent, raising the Tennessee River at Chattanooga, on March 11, 53 feet above low water; or 15.5 feet above any known water-mark. With the Cumberland, the Kentucky, the Green, and, indeed, all the lower southern tributaries discharging full floods into the Ohio, before the February rise had had time to pass away, this sudden Tennessee River flood raised the Lower Ohio to the highest stand ever attained. Fortunately the immense wave found the Mississippi burdened only with the previous rise, the Upper Mississippi, the Missouri, and the Arkansas all being low. The Washita, White, St. Francis, and Yazoo Rivers were swollen from the same rains, but probably not sufficiently to produce much effect upon the great wave from the Ohio, which arrived rather too late to coincide with their freshets. This flood in the Ohio was no less remarkable for duration than for extreme height—matters of equal importance in effecting a flood in an immense channel like that of the Lower Mississippi. For 32 consecutive days, at Cincinnati, (February 16 to March 19,) the mean channel depth was 51.3 feet, the greatest being 55.8 feet and 57.3 feet, on February 22, and March 14 and 15, respectively, and the least being 44.6 feet, on March 2 and 3. So long a continuance at this stage is beyond precedent.

These facts respecting the tributaries make it evident that the flood of 1867 in the Mississippi itself must have been marked by many peculiarities. In order to convey a clear idea of its character I have prepared the accompanying plate, drawn upon the same scale as that adopted in the Report upon the Physics and Hydraulics of the Mississippi, to illustrate the floods there discussed. [For plate referred to, see original on file in office of Chief of Engineers.] It will be noticed that, beside the oscillations at various points in 1867 and 1865, the plate contains other valuable river records, obtained through the kindness of Mr. Taylor and Mr. Bayley.

Since there was no great Mississippi flood above the mouth of the Ohio in 1867, Cairo is the first point which requires attention. It is a particularly important locality in all floods, being situated so near the head of the alluvial region that, when the source of the flood is known, a relative estimate of the maximum discharge into that district may be formed from a judicious study of the gauge indications there; but in this connection it is well to call attention to the following facts, which were fully established by repeated observations upon the Mississippi, and which, paradoxical as they may appear, are in perfect accordance with the laws governing flowing water.—(See page 324 Physics and Hydraulics of the Mississippi.)

1. For any given stand there is much more water passing when the river is rising than when it is falling.

2. For any given stand there is usually more water passing in a long and rapid than in a short and slow rise; but this is not always the case, the discharge being governed by the relative stage of the water in the channel above and below.

3. The maximum discharge in any normal rise occurs when the river has reached a point a few inches below the highest point attained.

4. If, when a freshet has culminated, and the water either comes to a stand or begins to fall, a second rise occurs, it will cause the surface to rise considerably higher than would have been the case had the same volume passed without a previous diminution of supply. For instance, in the flood of 1851, the Mississippi at Red River Landing attained a certain stage, with a measured discharge of 1,200,000 cubic feet per second. It had ceased to rise, and was just ready to begin to fall, with

a discharge reduced to 1,160,000 cubic feet, when the volume was again increased to 1,200,000 cubic feet. The river immediately rose to a point two feet higher than before. This was no isolated case, but was in strict accordance with general river laws, as is fully explained on page 363, Physics and Hydraulics of the Mississippi.

It is, therefore, carefully to be borne in mind that the maximum discharges of two floods are by no means necessarily proportional to the water level attained in them. Under some circumstances the lesser discharge may cause the higher water mark. These principles being understood, the facts connected with the flood of 1867 at Cairo will be considered.

At Cairo, on February 1, the river was at an ordinary low stage, the water surface reacting 3.9 on the gauge of the Cairo City Company; on the morning of the 2d it had begun to rise rapidly. The February freshets in the Upper Ohio culminated at Louisville on February 22, being eight feet below high water of 1832; that in the Wabash at Vincennes on the same date, rising half a foot above all known water marks, and that in the Mississippi at St. Louis, on February 21 and 25, being 12.6 feet below high water of 1858. The combined effects of these floods arrived at Cairo on March 1, bringing the river to a stand at about the level of the high water of 1858, (0.2 foot above that level at the foot of Twentieth street, and 0.3 foot below it near the junction of the two rivers.) This rise of 36.7 feet in 28 days was unprecedented. The river then gradually declined until, on March 8, it had fallen 0.9 foot; it then again slowly swelled until, on March 21, it reached its highest stand, (1.4 foot above high water of 1858 and 0.1 foot above high water of 1862, at the foot of Twentieth street, and 0.9 above the high water of 1858, and 0.3 foot below the high water of 1862, near the junction of the two rivers. These discrepancies in the flood level must always be excepted at Cairo, unless the water surface is taken at the junction of the two rivers. Thus, Mr. Hely, city engineer, reports that on March 18, 1867, he found the Ohio water to be 11.5 inches above that of the Mississippi at the north junction of the Cairo levees, the stations being 60 feet apart.) This second swell, of course, was due to the arrival of the combined Upper Ohio, Cumberland, and Tennessee rise. After culminating, the river at Cairo fell nearly as rapidly as it had risen. (See Plate.)

What do these facts indicate respecting the maximum discharge into the head of the alluvial region in the flood of 1867? This discharge must plainly have occurred late in February, just before the first swell culminated, for the conditions at Red River Landing in 1851 were repeated in the second rise. The height attained in the first swell was not quite equal to the high-water level of 1858; but, since the rise was longer and more rapid, it will not be safe to estimate the discharge at Cairo at a less amount than it was in that year, which, accurately measured, was 1,420,000 cubic feet per second. Since there was no overflow into the St. Francis bottom between Cape Girardeau and Cairo in 1867, this amount represents the whole of the maximum volume poured into the alluvial region near its head in that year. In 1858, at the date of maximum discharge at Cairo, 35,000 cubic feet per second were passing through Cape Girardeau Inlet, and 20,000 cubic feet over the banks, between Commerce Bluffs and Cairo, giving a total maximum discharge into the alluvial region of 1,475,000 cubic feet per second, or 55,000 cubic feet more than in 1867.

Without claiming exact accuracy for this estimate of the maximum volume to be kept in the channel in 1867, by a perfected levee system, it is hardly possible that any error equaling 55,000 cubic feet per second

can exist in it. Clearly, then, levees computed for the flood of 1858 would have restrained that of 1867, at least as far as the mouth of the first tributary below the Ohio. To this point, Helena, we may therefore turn our attention.

At Helena, the first rise culminated about March 14, standing one foot above high water of 1858, and 0.8 foot below high water of 1862. The river then subsided about 0.3 foot, but again swelled to its highest point during the year, on April 1, being then 0.2 foot above the mark of the first rise. In the next twenty days it gradually subsided about five feet, remained steadily at this level for three weeks, and then fell rapidly. (See Plate, both Helena and Friar's Point.)

Those facts strongly confirm the inference derived from the Cairo records, that the maximum discharge in 1867 was materially less than in 1858. In the latter flood the highest water was due to the immense wave which poured through the St. Francis bottom lands into the river, already swelling with water from above. This sudden influx, combined with the nearly simultaneous breaking of several immense crevasses immediately below Helena, lowered the actual high-water mark anomalously about 3.2 feet. (See page 406, Physics and Hydraulics of the Mississippi.) In 1867 the records indicate no such influences. The St. Francis River, in 1858, was contributing 30,000 cubic feet per second of rain-water to the Mississippi at the time when the great wave, if restrained to the channel, would have passed; and there is no reason for estimating a larger supply in 1867. Hence, had no anomalous influence lowered the high water of 1858 at this locality, the river would have risen $3.2 - 1 =$ say two feet above the level attained in 1867. But the actual maximum discharge in 1858 was 1,334,000 cubic feet per second; two feet lower, it would normally be about 1,234,000 cubic feet per second, which was probably the maximum discharge in 1867. Hence, for the volume absorbed in 1867 in filling the bed of the river between Cairo and Helena, and thus producing the rises in that district between the dates of highest water at the two localities, we have $1,420,000 - 1,234,000 = 186,000$ cubic feet per second. The actually measured effect of this channel influence between these two points in the March rise of 1858 was 140,000 cubic feet per second, (see page 349, Physics and Hydraulics of the Mississippi,) and as the general filling of the channel was much greater in 1867 than in March, 1858, such an excess (46,000 cubic feet) in 1867 is to be anticipated, as called for by the facts known respecting the river in that flood. In fine, then, the conclusion reached from the Cairo records that the head of the alluvial region received about 55,000 cubic feet per second less water at the date of maximum discharge in 1867 than at the same time in 1858, is surprisingly confirmed by all the facts noted at Helena.

The next point where an accession to the flood wave could have occurred is Napoleon, just below the joint mouths of the Arkansas and White Rivers. The oscillations at Beulah (see Plate) represent very nearly those which must have occurred at this locality. Unfortunately the cut-off which was made here in 1863, renders it impossible to apply a close analysis to the water-marks of the two floods. It is a matter of record that there was a moderate freshet in both of the tributaries (particularly in White River) in March, 1867, but that at the date of highest water at Napoleon, (April 3,) the current of the Arkansas was almost checked for 53 miles above its mouth, by back-water from the Mississippi. In 1858 the maximum flood wave, if confined to the channel, would have received about 60,000 cubic feet per second from these two tributaries, making its volume 197,000 cubic feet per second larger than the actual

maximum discharge. Starting with 55,000 cubic feet per second less, and being much more depleted in its passage by the necessity of filling a comparatively empty channel, the flood wave of 1867, if confined by levees, would have required immense contributions from the Arkansas and White Rivers to raise its volume to that of 1858 at Napoleon. Such contributions, we know from the recorded facts, it could not have received. Indeed there is little doubt that its maximum discharge would have fallen short of that of 1858, from 50,000 to 100,000 cubic feet per second at Napoleon. By no possibility could it have equaled that flood.

Vicksburg, below the mouth of the next tributary, Yazoo River, is now to be considered. The two cut-offs recently made in this vicinity, Terrapin Neck in March, 1866, and the Davis cut off in February, 1867, render any close analysis of this flood by studying the water-marks impossible. There are indications that at the date of highest water, the Yazoo River was discharging a considerable volume, the supply probably consisting, as is usually the case, largely of water returning from the swamps. In 1858 the great flood wave, if confined to the channel, would have received 30,000 cubic feet per second of rain-water from this tributary, and the facts reported do not lead to the conclusion that this contribution would have been much, if any, exceeded in 1867. Certainly any possible excess would have fallen far short of the amounts required to produce an equality of discharge in the floods.

In Red River there was a considerable flood in June, and probably a moderate rise in March, due chiefly to contributions from Washita River. Precise facts, however, have not been secured respecting this tributary, which is the last that enters the Mississippi.

In fine, then, the information collected respecting the flood of 1867 renders it certain that a thorough levee system, based upon the flood of 1858, would have been amply sufficient to protect the whole alluvial region from overflow. At no point would the water have risen to within one or two feet of the mark which would have been left by the flood of 1858, had it been strictly confined to the channel. Yet the actual water-mark of 1867 was, in general, a little higher than that of 1858. This apparent discrepancy is easily understood when it is remembered that there has never yet been a high-water mark not lowered by crevasses discharging into the swamps, the amount of the lowering varying greatly with the locality and with the peculiar conditions of the flood. The more perfect state of the levees in 1858 kept the swamps comparatively empty early in the season, and thus left a reservoir which, when they broke at date of maximum discharge, served to reduce the high-water mark more than was the case in 1867; the swamps having been early filled in that year. No more palpable error can therefore be committed than to attempt to estimate the relative difficulty of restraining different floods to the channel by simply comparing their actual water-marks. It is only by an analysis like the preceding that any well-grounded opinion can be formed upon such a matter.

Flood of 1865.—Occurring just at the close of the war, no facts have been preserved upon which to base a close analysis of this flood. The foregoing table exhibits how its water-marks compare with those of 1858. Rising to a less level at Cairo by 1.6 foot, there is no probability that the flood of 1865 equaled that, or even the flood of 1867, in maximum discharge into the head of the alluvial region, upon which, of course, the difficulty of restraining floods primarily depends.

The daily oscillations at Cairo and at New Orleans, the former recorded by the engineers of the Cairo City Company, and the latter by Mr. Bayley, are represented upon the accompanying plate. They give

a good general idea of the flood, which seems to be remarkable for duration rather than for extreme volume of maximum discharge. Applying the principles and table given upon page 133, Physics and Hydraulics of the Mississippi, to the New Orleans curve, the total annual discharge there in the river year, November 1, 1864, to October 31, 1865, is found to be 20,788,000,000,000 cubic feet, much less than that usual in great flood years, (about 27,000,000,000,000 of cubic feet.)

The facts collected respecting the action of the chief tributaries are meager. There was a great flood of the Upper Ohio in the middle of March, which at and above Cincinnati seems to have compared favorably with those of 1862 and 1867. It probably received relatively small contributions from the Wabash, the Cumberland, and Tennessee, for at Cairo its height was materially less. There was no great flood in that year in the Upper Mississippi or the Missouri, since the record at St. Louis shows that the river there hardly rose above ordinary stages in any month except in the latter part of July and August, when a little freshet occurred, causing the river for about five weeks to average ten feet above its usual stage at that season. No records of any great flood in the Arkansas or White Rivers are in my possession, but they are too defective to render it certain that none occurred. In Upper Red River a freshet in June is mentioned, and the fact is recorded that, at the mouth of Bayou Tensas the flood rose 1.8 foot above all previous marks, a circumstance no doubt explained by the immense crevasses in Carroll and Madison Parishes. It is also a matter of record that Bayou Teche overflowed its banks in low places as far up as Franklin, and that the high water at Brashear City, on Berwick's Bay, was only one foot below the great flood of 1828. These facts, due also to crevasses, probably explain the small annual discharge at New Orleans as compared with other flood years.

In fine, then, we may confidently place the overflow of 1865 in the second class of great floods in which the maximum discharge, with perfected levees, would have fallen far short of that quantity in 1858, or even in 1867.

Flood of 1862.—Beyond a doubt this was one of the greatest floods which ever occurred upon the Mississippi, and it is extremely to be regretted that the war raging at the time has so obliterated all records that it must always remain classed with the traditional overflows of 1815 and 1828, respecting which we do not possess the data to permit a close analytical comparison with the standard flood of 1858. Even the able engineers of the Cairo City property, whose daily river records are doing so much for the proper understanding of the hydraulics of the Mississippi, failed to record the history of this flood, only preserving its extreme high-water level, (attained on May 2,) to remain a standing subject of perplexing speculation for future students of the river.

We know that there was a very great flood in the Ohio River at Cincinnati, and also in the Cumberland River some time in the spring of 1862, and a destructive overflow in the Wabash in February. There was also a moderate flood in the Mississippi at St. Louis, which began to rise on March 12, from a stand 26 feet below the city directrix, and culminated on April 26, at 2.4 feet below that bench. It then gradually subsided until, on June 9, it stood 15 feet below the directrix. It remained above and within two feet of this level until July 26, when it slowly subsided to the usual low-water stage, (about 25 feet below the directrix.)

At Cairo the highest water occurred on May 2, and was 1.2 foot above the high water of 1858. Its date evidently corresponds to that of the

freshet of St. Louis; but this freshet, 5.7 feet below the high water of 1858, could only have produced such a rise at Cairo by combining with the great Ohio flood. How did these freshets meet? If, as was the case in 1858, they united so exactly at Cairo as to raise the river uniformly for the last 8 or 10 feet up to high-water mark without any intermediate stand or slight fall like that at Red River Landing in 1851, or at Cairo in 1867, then the maximum discharge must have exceeded that of 1858 by about 50,000 cubic feet per second. But even supposing this to have been the case, it is very certain that a flood 5.7 feet below that of 1858 at St. Louis could not have risen nearly so high at Cape Girardeau, and thence to Cairo; and hence could not have lost the 55,000 cubic feet per second, or any large part of it, into the St. Francis bottom lands. Under no supposition, then, could the flood of 1862 have discharged a larger volume into the head of the alluvial region than the flood of 1858. If, as in 1867, there was a slight recession at Cairo just before the extreme high-water mark was attained, due to a slight want of coincidence in the floods of the two rivers, it is probable that, as in that year, the maximum volume contributed to the alluvial region fell short of the discharge in 1858 by perhaps 50,000 cubic feet per second. The want of recorded facts at Cairo must always leave this a matter of doubt, and the most unfavorable theory must therefore be adopted, namely, that the two floods were equal in maximum discharge into the head of the alluvial region, (1,475,000 cubic feet per second.)

Between Cape Girardeau and Napoleon, then, we may safely consider that levees raised to the grade required to retain the flood of 1858 would have been severely taxed in 1862, but that they would have been sufficient. The only supposable conditions to cause their failure would be that the flood-wave had found the lower river more full than it was in 1858, which, under the conditions of the latter flood, would be extremely improbable.

At Napoleon the flood-wave in 1862 received a moderate freshet from the Arkansas, and probably from the White River also. This is established not only by the records, but also by the recorded date of high water, April 20. It is plain that the Arkansas flood was the earlier of the two; and very possibly if the river had been confined by levees, no dangerous coincidence would have occurred. In the condition of the records, however, this must always remain a matter of doubt.

It is believed that there was no flood in the Yazoo or Red Rivers at date of high water in 1862, (except water returning from the swamps,) but the records are too defective to render this certain.

In fine, then, as already stated, the flood of 1862 must probably always remain a source of anxious perplexity to engineers having the direction of the levee system of the Mississippi. The actual high-water marks of that year generally exceed those of any other by several inches, (see table already given;) but, as fully explained above, this proves absolutely nothing respecting the relative difficulty of restraining these floods had the levee system been perfected at their date. In my judgment, the only conclusion which the facts will warrant is that the two floods were essentially equal in the strain to which they would have subjected a general levee system; but that the recurrence so soon of so dangerous a flood should decisively forbid any reduction upon grounds of economy, of the dimensions calculated to restrain the flood of 1858. They are the minimum consistent with safety in the first class of Mississippi floods. Fortunately this class is rare. It is certain that such a system would have been severely tested during the last forty-five

years only in 1828, 1858, and 1862, or upon an average about once in fifteen years.

It may be permitted, in this connection, to invite attention to the importance of preserving hereafter full records of the oscillations of the Mississippi, and of the dates, heights, and duration of the freshets of its larger tributaries. Such records are absolutely indispensable to any judicious treatment of the problem of protecting the alluvial region against overflow.

ESTIMATES FOR A PERFECTED LEVEE SYSTEM.

It may, then, be considered as established that the floods which have occurred since the publication of the Report upon the Physics and Hydraulics of the Mississippi do not call for any modification in the theory or in the dimensions of the embankments therein projected. Their height was determined by close calculation from actual measurements made upon the flood of 1858 between Cape Girardeau and the Gulf. These measurements were so exact, so extensive, and so elaborate, that the complete history of the great wave which entered the alluvial region in June was traced out, determining where, when, and in what quantities the surplus waters both left and returned to the channel. This enabled a precise estimate to be made of the amount by which the actual measured maximum flood volume, at any point, fell below what it would have been had no water escaped, while a most thorough experimental study of the river rendered it possible to predict, with accuracy, the height to which the water would have risen above the actual local high-water marks had none left the channel. It was also proved, by extended soundings and measurements, that the bed of the river cannot be deepened by any slight increase in the velocity of its waters, and that no deposit in the channel need be dreaded from any slight reduction in its rate of measurement; in other words, that the bed is essentially unchanging in dimensions. Elaborate investigation also established that by no other plan of protection, except the levee system, could the surplus water in 1858 have been prevented from devastating the alluvial region. To accomplish this object, levees, raised to the following heights, were required:

Near the mouth of the Ohio they should be made about three feet above the actual high-water level of 1858, which has been selected as the plane of reference, because more unvarying than the surface of the ground. The height above this level should be gradually increased to about seven feet at Osceola; thence to Helena the latter height should be maintained. Thence to Island 71 the height should be gradually increased to ten feet; thence to the vicinity of Napoleon it may be gradually reduced to eight feet; thence to Lake Providence it must be gradually increased to eleven feet; thence to the mouth of the Yazoo it may be gradually reduced to six feet, and should be thus maintained to Red River Landing. Between that locality and Baton Rouge it should be kept uniformly about four feet; and below Baton Rouge about three feet. The above estimate is exclusive of settling, and allows about a foot for possible rise above the height necessary for restraining the flood of 1858.

The comparative tables of great floods in the Report upon the Physics and Hydraulics of the Mississippi and this report will render it easy to reduce any well-determined high-water mark to that of 1858, should the latter be lost at any locality.

The form of cross-section recommended for ordinary levees was the

following: The width of the crown to equal its height above the ground, with slopes of one on three toward the river, and one on two toward the land.

The estimates of costs were made by allowing twenty cents to the cubic yard of embankment, the usual price at the date of the report; at present rates forty cents is more nearly correct, and in this respect only will the basis of those estimates be now modified.

The only point not treated in the Physics and Hydraulics of the Mississippi, upon which estimates are now called for, is the project for protecting Northern Louisiana against overflow from the State of Arkansas, by means of a guard levee near the boundary line. Without new surveys no absolute answer can be given to this question. We know, as already stated, that to carry the present grade across the Bayou Tensas bottom lands would require an embankment 22,800 feet long and 10 feet high, containing about 300,000 cubic yards. But the grade of levees really necessary here is 8 feet higher than this, calling for an embankment containing about 950,000 cubic yards and costing about $380,000. Moreover, it is very probable that, to secure this increased height, the levees would have to be extended across the low ridge dividing Bayou Maçon from Bayou Bœuf, and also across the bottom lands of that stream; if so, the cost would not be less than $1,000,000, if, indeed, the natural drainage of the country would not render it absolutely necessary to leave Bayou Maçon and Bayou Bœuf open, which, with a Mississippi high-water mark raised 10 or 11 feet above that of 1858, would require a very extensive system of levees along these bayous. Hence, so far as the surveys at hand authorize any definite opinion, we must conclude that this plan for protecting Louisiana will probably involve an outlay of at least $2,000,000, even if it should prove to be practicable at all. One important point should not be overlooked, namely, whether, in connection with the guard levee and the bayous, a flood outlet, having a capacity of about 100,000 cubic feet per second, might not be practicable and safe. Such an outlet would lower the high-water mark of the Mississippi between two and three feet along the Tensas and Lower Yazoo fronts, and would thus materially reduce the cost of levees in this, the most difficult portion of the river. The natural capacity of the bayous below Lake Providence would permit such a volume to pass off without much damage to the plantations on their banks; but before the project should be attempted, extensive surveys ought to be made, and many borings, to decide whether the substrata of clay are thick enough to warrant a belief that the outlet might not unduly enlarge its capacity. The recent experience with the rapidly increasing cut at Providence does not seem to favor the project which, under any circumstances, would be very costly, beside being somewhat dangerous to the Black River country in case of a coincidence of large floods in the Mississippi and Red Rivers.

One other district deserves special attention in making estimates for a perfected system of levees—the St. Francis Bottom. As already stated, this region is peculiarly difficult to reclaim, because, although a unit geographically, it comes under the jurisdiction of two States; because the violent oscillations of the Mississippi along its front and their frequent recurrence, with the consequent rapidity of current, cause the river to erode its banks at an alarming rate; and because an unlucky system of swamp ridges diverts water at several points back in to the stream instead of allowing it to collect and return through the channel of the St. Francis River. To securely protect such a district requires strict attention to four points: 1st. To locate the main levee on

swamp ridges out of the reach of caving bends—say at least 1.5 miles from the fundus of each and all of them. 2d. To begin its construction at the north and extend south, and not the reverse, lest the work be destroyed before completed. 3d. To consider the local drainage of the back country, and to cut through such ridges as would cause rain-water lakes to be formed by the levee. 4th. To adopt a sufficient grade for the levee at first, and to carefully study the subject as the work progresses, with a view to modification, if necessary.

A levee thus made would reclaim about 3,000,000 acres of the best corn and cotton land in the world, capable of raising sixty bushels of the former or a bale of the latter to the acre, year after year without becoming exhausted. Its location would throw out much valuable land on the river bank, but this is a small consideration compared with the security of the back country. Local levees might be added at favorable points for local interests.

Since the war, a project has been started to combine levee and railroad in constructing an embankment, and thus to accomplish two results with one outlay. The projected route starts from the mouth of the St. Francis River, near Helena, follows the general route of the Mississippi, avoiding the bends, as far as New Madrid; here leaves the river and follows Big Prairie, a ridge above overflow, north, to connect with the Iron Mountian railroad of Missouri. Its embankment, if properly made and located, would effectually protect more than three-fourths of the entire district. The railroad company would be the best possible guard for the levee, as they would be compelled to keep it always in repair. Branch roads would furnish ready transportation for crops to Memphis or St. Louis throughout the whole bottom; and finally, the levee, being put to a useful purpose, in addition to its usual passive work of protection, could be made more thoroughly at less cost.

The surveys made by the Memphis and St. Louis Railroad Company were not elaborate, but they served to show that the length of the line from the mouth of St. Francis River to New Madrid, the only portion liable to overflow, was 170 miles, and that for about half of the distance (the only profile presented) the local high-water marks were about 5.5 feet above the ground. This would call for an embankment about 17 feet high, 12 feet wide on top, with slopes of one on three and one on two; contents 30,900,000 cubic yards; cost $12,360,000, or about $73,000 per mile. This amount is small compared with the railroad outlay often required in mountainous districts, and as the project is greatly superior to that of levees built along the river bank, upon which the estimates in the Physics and Hydraulics of the Mississippi were based, it will be adopted here as the best method of offering permanent protection to the swamp lands of the St. Francis district lying in Arkansas. Incidentally, a large extent of these lands belonging to Missouri would also be protected by the embankment.

The following table is partly a recapitulation of estimates already given, and is partly deduced from the table on page 420, Physics and Hydraulics of the Mississippi, allowances being made for the deterioration of existing levees since the date of that report, and the cost per cubic yard of embankment being taken at 40 cents instead of 20 cents. The column " for perfecting existing levees to present height" is given because, as they now stand throughout the greater part of the valley, they encourage delusive hopes of protection. Whenever the river rises three feet above its natural banks, disastrous crevasses are sure to occur: and if every break upon the river were now closed, any flood worthy of the name would be certain to open new ones in sufficient numbers to

devastate large areas of the alluvial lands. In other words, existing levees are as defective in cross-section as in height, and the cost of sufficiently strengthening them to resist the pressure of the floods would be a necessary outlay, even if the flood volume, when restrained to the river, should not rise above its present level. Some of the more recent embankments, and especially the levees of the State of Mississippi constructed under the direction of Mr. Meriwether as chief engineer, are not liable to this criticism.

Consolidated levee estimates.

	For repairing existing breaks.	For perfecting existing levees to present height.	For perfecting existing levees to proper height.
LOUISIANA.			
Below Red River, (both banks)	$600,000	$1,730,000	$4,600,000
Above Red River, (right bank)	200,000	800,000	8,420,000
To exclude water escaping above boundary	250,000	250,000	2,000,000
Total, say	1,050,000	2,780,000	15,020,000
MISSISSIPPI.			
Yazoo front	1,500,000	1,500,000	4,150,000
ARKANSAS.			
Louisiana to Arkansas River	700,000	960,000	4,700,000
White River to Helena	150,000	350,000	2,000,000
St. Francis bottom lands	1,000,000	1,600,000	12,360,000
Total, say	1,850,000	2,910,000	19,060,000
Grand total for the three States	4,150,000	6,940,000	36,230,090

The levees contemplated in these estimates are large—much larger than residents of the alluvial lands in general anticipate; but in the language of the report of 1866, they would not, when greatest, exceed in magnitude those on the right branch of the Rhine below Arnheim, which protect the most fertile part of Holland. These levees are exposed at high water to as strong a current as that of the Mississippi in flood, and also to the destructive effects of ice. But the occurrence of crevasses, such as take place with every great flood of the Mississippi, are there unknown. Should they happen, the ruin of a large part of the most productive portion of Holland would follow, as extensive tracts protected by the levees are lower than the surface of the sea, and their reclamation from overflow could only be effected by a drainage similar to that which has been applied to the lake of Harlem. The supervision, watching and repair of these levees is costly, but effective and remunerative. The levees of the Mississippi, as now existing, are trifling compared to the interests they protect, and to the levees of the delta rivers of Europe—the Po, the Rhine, and the Vistula.

The cost of the Mississippi levees, as indicated in the foregoing table, would not be trifling, but it should be remembered that the figures are based upon present inflated prices. The project can hardly be considered as beyond the limits of judicious investment, when it is remembered that the amount actually expended upon the Erie Canal exceeds $33,000,000, and this, too, mostly paid in gold. A slight idea of the profits

which may be anticipated, as compared with the necessary outlay, can be formed from the following facts. The total area of the bottom lands is about 32,000 square miles, of which a mere narrow strip along the main stream and its principal tributaries and bayous has been heretofore opened to cultivation. Protected against the river and properly drained this would render available at least 2,500,000 acres of sugar land, or more than double the amount heretofore planted; about 7,000,000 acres of the best cotton land in the world, capable of yielding a bale to the acre; and not less than 1,000,000 acres of corn land of unsurpassed and inexhaustible fertility. An expenditure of about $300 to the acre (present prices) of land actually made cultivable by the levees would thus be sufficient to reclaim them from overflow. Supposing the cotton lands alone to be under cultivation, a tax of one cent a pound for one crop would nearly pay the cost of the levees for the entire valley.

I am, general, very respectfully, your obedient servant,

HENRY L. ABBOT,
Major of Engineers and Brevet Brigadier General.

Major General A. A. HUMPHREYS,
Commanding Corps of Engineers.

APPENDIX.

As the three floods of 1862, 1865, and 1867 will no doubt often be studied and discussed hereafter, I have thought it advisable to append a brief abstract of the most important facts collected respecting each of the main tributaries, beginning near their sources and proceeding in regular geographical order toward their mouths.

OHIO RIVER.

Pittsburg.—The ice broke up on February 3, 1867, causing river to rise and immediately to fall eight feet. The next freshet began to rise rapidly on February 14. By February 15, it stood twenty-two feet by the Alleghany pier-mark and began falling. The largest freshet of the year attained its height, 22.3 feet by the Alleghany pier-mark, on March 13, and then rapidly fell. It was ten feet below high water of 1832, and eight feet below that of 1865, which was highest on March 18, and chiefly due to an Alleghany freshet.

Rochester, (26 miles below Pittsburg.)—The freshet of February 15, 1867, was higher by six inches than that of March 12, 1867, being 28.5 feet in channel. It was 13.5 feet below high water of 1832; 10.5 feet below that of 1852, and 7.5 feet below that of March 18, 1865, which was precisely equal to the 1860 and 1861 freshets.

Marietta, (171 miles below Pittsburg.)—River began rising slowly on February 9, 1867; attained highest point, 35 feet above low water, on February 17 and 18; fell slowly; began rising on March 9, and culminated on March 13 and 14, at a point twenty-eight feet above low water; then slowly receded. Downfall in February, 1.8 inch; in March, 5.3 inches.

Parkersburg, (183 miles below Pittsburg.)—River began rising on February 13, 1867; was highest—thirty-six feet above low water—on February 17 and 18; fell slowly. Its high-water mark was 2.5 feet below that of 1865.

Cincinnati, (466 miles below Pittsburg.)—The duration of the flood of

1867 was unprecedented. For thirty-two consecutive days (February 16 to March 19) the mean channel depth was 51.3 feet, the greatest depth being 55.8 feet on February 22, and 57.3 feet on March 14 and 15, and the least depth being 44.6 feet on March 2 and 3. The March rise was 0.6 foot below high water of 1865, and 1.3 foot below that of 1862. Immense local rains during flood of 1867.

Louisville, (618 miles below Pittsburg.)—The rise of February 22, 1867, was eight feet, and that of March 15, 2.8 feet below the high water of 1832. The March rise was a little below the high water of 1847. For five months snows and rains had been excessive, the downfall being estimated at three times the usual amount.

Wabash River.—In 1867 there was only one important rise, which occurred in February. At Eugene, Indiana, (three hundred and fifty miles above mouth,) by exact marks the high water of 1858 was the highest on record, being twenty-eight feet above low water. It was one foot above the high water of 1828 and 1844, four feet above that of 1851, and two feet above that of 1867. In latter years the river remained bank-full from the latter part of February until the middle of May; snows during winter and rains in March being excessive. In 1862 the high water occurred in February, and was very destructive. During the thirty-four years between 1833 and 1866 six crops have been lost from overflow. At Terre Haute the high water of 1867 was 1.3 foot below the high water of 1858, the highest on record, culminating on February 21 with river 25.3 feet above low water. The rise began on February 9. At Vincennes the river was out of its banks from February 19 to March 2, inclusive, being highest on February 22 and 23, when it was 0.5 foot higher than ever known before, (twenty-five feet above low water.) Snows and rains had prevailed during the winter.

Caseyville, Kentucky.—In 1867 the river began rising on February 1, and reached highest point on March 1, being then 0.5 foot above high water of 1832, and 4.1 feet above high water of 1847. The second rise culminated about March 16, and was 0.4 foot below the first, the fall between the two rises being about three feet; downfall during the winter was without precedent.

Cumberland River.—At Carthage the high water of 1867 was seven feet below that of 1826, four feet below 1847, and one foot below 1862; and was forty feet above low water. The rise began on February 25, culminated on March 9–12, subsided eight feet, but again swelled until March 25 or 26, when it finally fell. At Nashville the flood was 0.8 foot below the high water of 1847 on March 13. On Harpeth Shoals, thirty miles below, where extreme low water gives a depth of only thirteen inches, this flood stood sixty-four feet. The rise there began on February 28, the water standing nineteen feet. It culminated on March 13. After March 16, the river fell very rapidly, with no second swell. It was over banks (above about fifty-five on shoals) from March 8 to March 16, inclusive, indicating a flood of unusually long duration. At Eddyville the flood was 1.2 foot above high water of 1847 on March 18, the highest floods previously on record there.

Tennessee River.—The flood of 1867 far exceeded all precedents for the past ninety years. It consisted of one great rise due to furious rain storms which covered its entire valley, particularly the mountain region. At Kingsport, on the Holston, rain fell nearly continuously from February 28 to March 7. At noon of March 7 the river attained its highest point, being thirty feet above low water and four feet above any other flood. In twenty hours it fell ten feet. At Strawberry Plains the freshet rose fifty-two feet above low water, and eleven feet above any other flood.

At Knoxville the river rose twelve feet above high-water mark of 1847, and was over fifty feet deep. Near Harrison, the Tennessee rose fifteen feet above any known water mark. At Chattanooga the rise began on March 4, overflowed banks on March 8, and attained height on March 11, being fifty-three feet above low water and 15.5 feet above the high water of 1847, the highest on record. The river fell with equal rapidity to usual level. Rains were incessant for four days before highest water. At Bridgeport, Alabama, the flood reached its maximum, 11.5 feet above all former marks, late on March 12. At Bellefonte, Alabama, rise began on March 5, and was highest on March 13, when it was 9.1 feet above high water of 1847. At Decatur, the freshet culminated on March 16, being six or seven feet above any other flood; it remained stationary for two days. At Florence, Alabama, the freshet began on March 1, culminated on March 15, falling very slowly for three days. It stood six feet above all other floods. At Eastport it stood seven feet above any known flood. At Johnsonville the flood culminated on March 22, being 3.8 feet above all previous water marks, and 44.8 feet above ordinary low water; by April 1, it had returned within banks. At Paducah the rise culminated on March 21. The destruction of property and life occasioned by this flood was beyond parallel in the history of the Tennessee Valley.

Metropolis, (40 miles above Cairo.)—The February rise of 1867 was 1.5 foot below high water of 1847. The river remained nearly stationary until March 8, when it began to swell; it culminated on March 20 at a point above all previous water marks, being three feet above high water of 1865, and 4.4 above that of 1847. The fall was rapid.

Mound City, (6 miles above Cairo.)—The flood of 1867 rose 0.9 foot above high water of 1862.

UPPER MISSISSIPPI RIVER.

Fort Ripley.—No rain fell between November 26, 1866, and April 13, 1867; no spring rise in 1867.

Winona.—There were not twelve hours of rain between January 6 and April 13, 1867; no early spring rise, the river being frozen in March. The highest points reached between October 4, 1866, and April 22, 1867, were on December 24, when the river was 6.6 feet above low water, and on April 22, 1867, when it was 9.4 above low water and rising. The total range here is about 14 feet.

ILLINOIS RIVER.

At La Salle, eighteen inches of rain fell between February 5 and June 3, 1867. A freshet, rising within one foot of top of levees, culminated on February 17, 1867, being twenty-six feet above the low stand of February 3; the river remained high, but oscillating, until June 3, (date of letter,) the lowest point being about seven feet above low water on May 19.

MISSOURI RIVER.

Fort Randall.—The river remained frozen until April 9, 1867, being at low-water mark, or about five feet deep. It began rising on April 12, and on April 17–19 it was bank full, but it fell at once to usual summer level. (The freshet did no damage.) No local rains fell for the five months ending April 16.

Niobrara.—In March, 1867, about 2.5 feet of snow fell, and on April 17 about three inches of rain. On April 1 the river was at usual sum-

mer level, but a sudden and excessive (ten feet) freshet in the Niobrara raised it rapidly. Combined with the rise above, this freshet raised the Missouri on April 18 to a point 1.5 foot below the high water of 1858, and two feet below the high water of 1866, the highest recorded flood.

Omaha.—Ice broke up on April 7, 1867, the river being very low. The melting snows caused it to rise rapidly until, on April 23, it stood 18.8 feet above extreme low-water mark, (1863.) It was 1.9 foot above high water of 1866, and 0.1 foot above that of 1844. By April 30 it had receded within banks, a fall of about seven feet. The levees were completely overflowed.

South Platte River.—At Fort Sedgwick much snow fell in March, 1867. The mean temperature was very cold; and the river there, about half a mile mide and two feet deep at low water, was frozen solid. The ice broke up on April 8 with a little freshet.

St. Joseph.—The ice broke up on February 13, 1867, causing a little rise of five feet, due to melting snow and ice gorges. The highest stand in February or March was twelve feet within banks.

Leavenworth.—The Missouri was very low during March, 1867. Quite a freshet occurred between April 10 and May 9, the river being at these dates 5.5 feet above low-water mark. At its height, on April 27 and 28, it stood 18.6 feet above low water, and 0.7 foot above the mark of April, 1866. No damage was done by freshets locally.

ARKANSAS RIVER.

Fort Smith.—The high water of June, 1866, was 3.8 feet above that of 1862, and two feet above that of 1867.

Little Rock.—There were heavy rains and snows in March, 1867, which, however, flooded the White, Little Red, Washita, and Sabine Rivers, heading near the Arkansas, more than they did that river itself. Before the storms occurred the latter river was about three feet above low water; in two days after the rains began the river commenced to rise so rapidly that in about three days it rose twenty-five feet, to its highest point, which was six feet below high water of 1833, and 1.1 foot below that of August, 1866. The river rapidly subsided, doing little damage above the influence of back-water from the Mississippi.

Pine Bluffs.—In 1867 the river did not reach the top of its banks by some feet. The flood of 1833 is the greatest recorded. Next to it is that of 1844, which was occasioned by a general freshet in all the tributaries. The river began rising late in March; on May 8 and May 20 it reached the mark of 1833; about July 1 it retired within banks; on August 10 it attained low-water level. The construction of levees on the lower Arkansas, since 1844, has affected the relative heights of later floods.

Heckatoo Plantation, (15 miles above South Bend.)—In 1862 there was no great flood in the Arkansas river itself. In 1867 the waters rose 0.3 foot above high water of 1866, which reached a higher point than any other flood since 1844. There were several crevasses near and below this plantation in 1867.

South Bend.—The date of highest water in 1867 was June 7. About four miles of gaps in Arkansas River levees in vicinity. A moderate flood in Arkansas River at date of high water in 1862.

RED RIVER.

Cut-off Landing, (nearly west of Lewisville, Arkansas.)—There was an overflow in May and June, 1867, damaging about three-fourths of crops.

The highest water was about 0.3 foot above high water in June, 1865, and April, 1866.

Shreveport to Alexandria.—On June 22, 1867, the river was falling fast. The flood had caused very considerable damage in this region.

APPENDIX N.

U. S. ENGINEER OFFICE, OHIO RIVER IMPROVEMENT,
Pittsburg, Pennsylvania, August 5, 1869.

GENERAL: In obedience to instructions contained in circular of the Engineer Department, dated June 12, 1869, I respectfully present the following annual report upon the surveys and works temporarily under your charge for the improvement of the Ohio River, for the fiscal year ending June 30, 1869:

SURVEYS.

At the date of the last annual report, (September 15, 1868,) no reports had been received from the engineering parties under Sigismund Löw, assistant United States civil engineer, and George Barrett, assistant United States civil engineer, engaged upon the surveys of those portions of the river below Louisville left from 1867. The upper party, under Mr. Barrett, resumed the survey in the latter part of July, 1867, where it had been suspended by Mr. James E. Day, in the fall of 1867, at Cloverport, Kentucky, 705 miles below Pittsburg, and 108 miles below Louisville. Mr. Barrett's party reached Evansville, 783 miles from Pittsburg, September 23, 1868. From Evansville, Mr. Barrett was ordered to pass over Mr. Löw's district, and resume his survey at Hillerman, 939 miles below Pittsburg. By the 21st of October, the shore line was completed to Cairo, mouth of the Ohio River, 967 miles below Pittsburg. Mr. Barrett remained with a reduced party to take soundings at the Grand Chain, which he had been prevented from doing on account of the high stage of water. The operations of his party in the field were closed November 7, 1868. The entire distance surveyed by Mr. Barrett was 106 miles. Owing to the high water, the party was unable to take soundings between French Island and Evansville, a distance of 23 miles. The season was also unfavorable throughout for arriving at the correct low-water fall at the several ripples, their level line showing for long distances only the average slope of the river. The party under Mr. Löw began their field work July 28, 1868, where they had quit in 1867, at Slim Island, 42.4 miles below Evansville. The party reached Hillerman, where Mr. Barrett had resumed, October 8. The whole distance surveyed by Mr. Löw's party in 1868 was 114.4 miles. Mr. Löw's party experienced much sickness during August and September, particularly in the region of the mouth of the Wabash River; at one time eleven out of seventeen were laid up with the fever and ague. Both in Mr. Löw's and Mr. Barrett's parties the sickness caused considerable detention, the assistants being unable to work up their maps until some time after their return to Pittsburg. Mr. Löw was prevented by the high water from taking soundings between Smithland, mouth of the Cumberland River, and Hillerman, a distance of 31 miles.

The surveys of the Ohio River were begun under Captain, afterwards Major John Sanders, United States Corps of Engineers, in 1836, and continued by him through 1837 and 1838. Resumed in 1844 by Mr. Fuller, of the Engineer Bureau, who surveyed 37 miles; making 271 miles completed at the close of 1844. The surveys were again resumed by Mr.

Roberts in 1867, and completed, with the exception of some soundings as mentioned above, November 7, 1868.

During the year the engineering party under my charge, with Captain George W. Rowley, consulting pilot of the engineer steamer Tidioute, in addition to their duties of superintending the construction of riprap dams, dredging, &c., made a number of special surveys and reports. In August, 1868, the Tidioute went as far down as Louisville, having all the charts along, and many places which had been omitted on account of high water were sounded over thoroughly. Accurate surveys of Wheeling and Marietta Island were made in the fall of 1868, by this party, and during this season a survey of Grandview Shoals and Sheet's Ripple was made; all points where work is at present in progress. One of the immediate results of the survey of the Ohio was a correction of the distances along the river. Heretofore various and conflicting estimates were employed by the pilots, giving rise to considerable trouble and confusion. A table of distances was furnished for publication to the papers in Pittsburg and Cincinnati, so that now it is presumed all river-men are furnished with a reliable table. The office work upon the maps was so much delayed by sickness and absence of the assistants who made the surveys, that it was not until recently that the draughtsmen in the office completed the details upon them. There are 118 charts, beginning at Pittsburg, 32 of them surveyed by Captain Sanders and Mr. Fuller, embracing a distance of 271 miles. The entire length of the river being 967 miles from Pittsburg to Cairo, these charts represent, on an average, each eight and one-fifth miles of the river, drawn to a scale of 1,000 feet to the inch.

The department has authorized further local surveys, principally soundings and leveling, to be done, to fill out the maps and profiles prior to a thorough report upon the surveys being made.

WORK ON THE RIVER RIPRAP DAMS AND DREDGING.

In the last annual report was presented a table exhibiting the amounts paid up to June, 1868, at nine points, being the first points advertised for improvement at the commencement of our operations. The following table exhibits the quantity of work done at such of those points which were not finished, and the amount of work done on supplementary contracts, from June, 1868, to July, 1869.

Table exhibiting the amount expended on works along the Ohio River from June, 1868, to July 1869, inclusive.

No.	Miles from Pittsburg.	Place.	Contractors.	Amount paid.
1	2	Brunot's Island	B. L. Wood, jr.	$729 00
2	11	White's Ripple	Routh & Watts	3,239 00
			Swan & Fenton	3,645 00
2	11	White's Ripple, (dredging)	B. L. Wood	2,070 00
3	14	Deadman's	B. L. Wood	3,400 00
4	18	Logstown Bar	Routh & Lane	5,260 25
5	27	Beaver Shoals	B. L. Wood	6,121 00
5	27	Beaver Shoals	James Bradley	1,620 00
6	85	Twin Island	T. J. Power	2,493 00
7	90	Wheeling	Routh & Watts	2,812 50
8	107	Captina Island	Myers & Kerr	380 70
9	143	Grandview	James Bradley	4,252 00
10	144	Sheet's Ripple	C. M. Cole	4,567 00
11	167	Marietta	Routh & Watts	11,250 00
12	174	Muskingum	C. M. Cole	6,004 64
13	185	Blennerhassett's	C. M. Cole	2,553 07
14	202	Belleville Island	C. M. Cole	1,111 50
15	214	Buffington	Henry Baker	4,374 00

White's Ripple, (11 miles from Pittsburg.)—In last annual report a detailed statement of the condition of the dams at this place was made; the construction of the cross-dam and some dredging to widen the tow-boat channel was at the same time recommended. The contracts have since been made, but owing to the remarkably high water this spring but little work has been accomplished beyond quarrying the stone. During the fall of 1868, the work at dredging was done; 2,000 cubic yards of gravel having been removed, and although the dam is still unfinished, a material improvement has been made by the dredging alone.

The contractors will be able to finish boating the stone to White's Ripple during September.

Deadman's Island, (14 miles from Pittsburg.)—The difficulty at this point was, that by the land-owners having changed the course of the Sewickley Creek so that it came into the river opposite Deadman's Island, half a mile below the old mouth, a flood from the creek in August, 1868, filled out a bar at its new mouth.

The place had been difficult for tow-boats before on account of its crookedness, but was then much worse, ascending boats having to "warp" through at a four feet stage.

Owing to low water it was not until November 1 that the dredge-boat got fairly to work.

During the season 4,000 cubic yards were removed, and the channel made straighter and better than formerly. No additional work seems to be required at this point.

Logstown Bar, (18 miles from Pittsburg.)—The dam at this place was finished in July, 1868, and remains in good condition. It has greatly improved the navigation, more particularly for the coal-boat interest.

Line Island, (41 miles below Pittsburg.)—There is a small bar to the left, at the head of the channel at Line Island, which greatly narrows the navigable channel. The channel chute of the island is much less than the average width of island's channels. Owing to the high water this season the work at the removal of 500 cubic yards of this bar has not been commenced.

Beaver Shoals, (27 miles below Pittsburg.)—This difficult reach of navigation has long been a source of annoyance to coal-boatmen, and to all navigators. The channel for a mile or more was quite crooked, passing around gravel and boulder bars, which were often struck, causing many losses by sinking, &c. Captain Sanders, in 1844, proposed an improvement, and began work at excavating a channel close along the left shore. There is a natural "pocket" or channel along that shore for a considerable distance, but at the upper end it would require a large quantity of rock blasting to make it sufficiently wide to accommodate the commerce of the present day. A contract for a riprap dam to shut off the water taking down the left shore, (3,500 cubic yards,) and dredging, (11,000 cubic yards,) was made last fall. At the present time the stone for the dam is on the bank, and will be boated in as soon as possible. The dredge-boat, belonging to B. L. Wood, jr., began operations May 26, at the main bar at the upper end of Beaver Shoals. This bar was about 700 feet long, with an average width of 90 feet, and composed almost entirely of boulder; some of these measuring a cubic yard, while the average were too large for street paving purposes. Notwithstanding the natural difficulties of the place, and the almost continuous high water, interference of rafts and coal-boats which several times forced them to quit work, the work has proceeded well. At the present time, (August 10,) fully 8,000 cubic yards have been removed; some of which was taken from a bar at the lower end of the shoal. The machine is now at work

taking off a few lumps which were unavoidably left, after which there will be a comparatively straight channel through Beaver Shoals.

Brunot's Island, (3 miles from Pittsburg.)—In addition to the rocks which were taken out of "Rowley's Channel," at the mouth of the Chartiers Creek, in 1867, it was found advisable to dredge the channel to make it wider for tow-boats.

The dredge-boat employed at Beaver Shoals worked at this point early in the season; upon her return to Pittsburg, some lumps left at that time will be removed, when the navigation of Brunot's Island will be as easy as elsewhere on the river. Formerly, boats had to lay up in Pittsburg when there were ten inches to spare for them on any bar below.

Twin Island, (85 miles below Pittsburg.)—Since the last annual report a contract for 1,600 cubic yards of stone to repair damage to the long dam at Twin Island was made. Included in the estimate was the construction of a short dam to confine the waters at the shoal to the right of central bar, at the foot of upper island, as recommended in that report.

Some work was done upon this place last fall; a little stone has been placed at the foot of the upper island. This season the river has been too high, until recently, for the resumption of work. It is expected that all the stone authorized in the contract will be boated in during September. I have been unable to critically examine this place on account of the high water. The dam passes over a soft gravel bar for several hundred feet, and may require some stone in addition to that under contract. Dams in such situations require several years' time to become firmly settled.

Wheeling Island, (90 miles from Pittsburg.)—Wheeling Island was thoroughly surveyed last fall, and a map and a report upon several plans proposed for its improvement forwarded to the department. The difficulty in the navigation of the left and only regular channel at this island consists of a wide shoal bar at the upper end, opposite Jonathan's Gut Run, and another shoal below the Wheeling city landing, at the mouth of Wheeling Creek. Owing to the nature of the shoals above, at Burlington, it was not deemed advisable to resort to dredging as the only means of improvement at this place.

The quantity of water passing at the lowest period in 1868, called fourteen inches in the channel, I found to be 137,000 cubic feet per minute on the east or Wheeling side, and 43,000 cubic feet per minute on the west or Bridgeport side of the island; total, 180,000 cubic feet per minute.

The proposed dam at the head of the island met with so much opposition by the citizens of Bridgeport, Ohio, that it was finally ordered to be constructed across the Ohio chute, below the covered bridge, leaving an unobstructed entrance to that town from above.

The dam is now in progress of construction. In addition to the dam, the lower bar at the mouth of Wheeling Creek will be improved by scraping, a contract for 2,000 cubic yards of dredging having been recently entered into for that place.

Cable's Eddy, (66 miles from Pittsburg.)—A contract for the removal of 150 cubic yards of rock, interfering with the coal-boat navigation at this place, was made last fall. The river has remained too high for the work until recently.

Captina Island, (108 miles from Pittsburg.)—At the date of last annual report it was recommended that 500 cubic yards of stone be applied to repair the dam at Captina Island. During the fall of 1868 a contract for repairs to that amount was made, and 180 cubic yards were

placed on the dam. The river has been too high this season to close the work; the work will be resumed immediately, and it is expected it will be completed by September 15.

Fish Creek Island,(113 miles from Pittsburg.)—At date of last annual report an additional quantity of 400 cubic yards of stone was estimated for repairs here. The contract for the work was awarded to the same parties that have Captina. The high water has interfered with the work, but it is expected the repairs will be done here during September.

Grandview Shoals, (142 miles from Pittsburg.)—A dam was planned for the improvement of this shoal last year. This season a thorough survey has been made, and the dam located. It will require 4,800 cubic yards of stone. Owing to the high water the contractors do not hope to complete it before October 1. The dam will be built out from the Virginia shore, and will be about 1,800 feet long.

Sheets Ripple, (144 miles from Pittsburg.)—A survey of this place was made in connection with Grandview Shoals, and a similar dam located.

The contractor at this place has been unceasing in his endeavors to complete the dam at an early period, and will have it completed during the present season. The contract is for 4,800 cubic yards.

Petticoat Bar, (146 miles from Pittsburg.)—The dams at Petticoat Bar were finished in 1867. No additional work has since been found necessary. The channel at this point has been greatly improved.

Rowland's Race, (159 miles from Pittsburg.)—A contract for 1,200 cubic yards of dredging to straighten the channel at Rowland's Race was made last fall, since which time, on account of the high water, no work has been done. The contractor will begin operations as soon as his arrangements are completed.

Marietta Island, (167 miles from Pittsburg.)—A contract for 11,000 cubic yards of stone to close one of the chutes of this island was made last fall. If the Virginia chute be closed there will be a surplus sufficient for the construction of a low wing-dam at Carpenter's Bar, one and mile above.

Carpenter's Bar is really somewhat shoaler than either chute of the island, but it is believed that a dam at the head of Marietta Island will of itself greatly improve the place.

There is no trouble at Marietta, except during low water, so that a dam can be of little benefit to the descending coal trade. Naturally, the Virginia chute is somewhat the best. The citizens of Marietta object to a dam closing the Ohio chute, believing that the chute will close up with sand, and destroy the landing at their prosperous city. In this remonstrance they are seconded by the pilots and officers of all the regular packet lines engaged in the navigation of the Upper Ohio. Some of the Pittsburg coal-boat men, on the other hand, remonstrate against closing the Virginia chute, the one usually run by the coal fleets. Their objection is that they fear snags and sand-bars in the Ohio chute. I made a thorough survey of this place last fall, aided by Captain G. W. Rowley, United States consulting pilot, a man of excellent knowledge of the river, and of good judgment. These reports and maps furnish all the details showing the feature of the place. We have recommended, only on account of the town of Marietta, that a dam be built closing the Virginia chute. We believe that the bars complained of are not sufficiently high to interfere with coal-boat navigation, and that a dam will help to keep it cleaner. No plan by means of dredging alone seems at all advisable for the improvement of the shoals at Carpenter's Bar and Marietta Island.

About 10,000 cubic yards of stone have been quarried and delivered on the river bank this season, and are now ready for delivery.

Muskingum Island, (174 miles from Pittsburg.)—For reasons stated in last annual report the dam at Muskingum Island remained unfinished. The dam was not finished until November, 1868, and thus far requires no additional work. One noticeable effect of the construction of this dam was witnessed at Marietta, three miles above, the lower bar at the entrance to that town being improved several inches by the backwater. To further benefit that place it might be found advisable sometime in the future to build the dam at Muskingum Island somewhat higher, though the necessity for future work is not apparent for the purpose of general navigation.

Blennerhassett's Island, (185 miles from Pittsburg.)—In the last annual report a general description of the dams at Blennerhassett's Island was given. The contract for work here was closed in November last, at which time all the dams were in good condition. The dam at the head of the island was particularly troublesome to build, having sunk and washed so much during the progress of the work that the estimated quantity of stone was barely sufficient to shut off the water.

The river, so far this season, has been too high below Parkersburg to examine very thoroughly into the condition of the work, but it is believed no additional stone will be required upon the dam at head.

The semicircular dam on the right, at the foot of the island, (four miles below,) it is believed, should be built somewhat higher to prevent heavy coal fleets from drifting against it. The place will be reported upon as soon as possible. For low-water navigation this place has given no trouble whatever since the dams were begun, in 1867, prior to which time it was only next to Buffington Island, of the bad points in this part of the river.

Mustapha Island, (194 miles from Pittsburg.)—Rocks in the right chute of Mustapha Island will be removed as soon as the water permits; these rocks interfere with the low-water navigation. A contract was made last fall for the removal of 150 cubic yards.

Belleville Island, (202 miles from Pittsburg.)—A contract for 3,500 cubic yards of stone was made for Belleville Island last fall. About 1,300 cubic yards are quarried on the bank ready for delivery. The object of the dam is to shut off the water escaping to the left of the channel at the foot of the island. The water has interfered with the work this spring, but the whole will be finished this fall.

Buffington Island, (214 miles from Pittsburg.)—At Buffington Island it was estimated in last annual report that 3,000 cubic yards would be required to repair the dam closing the Ohio chute of the island, and in extending the long dam in the Virginia chute. A contract for that amount of work was made last summer, and by the end of the season 2,200 cubic yards of stone were placed in the dam. The remaining 800 cubic yards are now ready for delivery. At the same time a contract for 1,000 cubic yards of dredging was made. The coal fleets have great difficulty in passing between the bars without striking one or the other; a further contract of 4,000 cubic yards of dredging was made recently; none of this dredging has yet been done. It is believed that, with the work now finished and now under contract, this difficult place will be radically improved, both for the low-water and coal-boat navigation.

WORKS ON THE RIVER BELOW CINCINNATI.

Contracts for riprap dams at Medoc or Bosley's Bar, 448 miles from Pittsburg; Rising Sun Bar, 502 miles from Pittsburg; and Warsaw

Bar, 524½ miles from Pittsburg, were made in July of this season. At Rising Sun Bar and Warsaw Bar some dredging in the channel is under contract.

The successful bidders for these works have not yet completed their preparations for work, but it is expected that work will be in progress by the middle of September at all the points now under contract on the river.

In my general charge of the works in the field, I was greatly assisted by Captain George W. Rowley, United States consulting pilot. Captain Marshall Hays, an old experienced pilot, is also engaged aiding in directing and personally superintending the dredging operations.

NEW WORKS.

No funds are available for much more work than is described above. The list above embraces those points generally recognized as the most troublesome; but with their improvement comes the necessity for the improvement of places only a little worse.

The following points above Louisville are those now most urgently requiring improvements. The estimates have been carefully revised; the charts so far completed show all points above Louisville very perfectly; other minor points might be added, but, in advance of any appropriation, may not be necessary. To this estimate for the further extension of improvements on the Ohio River should be added a like amount for the Lower Ohio. The high water at the time of surveying much of the Lower Ohio has prevented as much accuracy in preparing estimates as in the portion above the falls. At the same time it seems not altogether improbable that a somewhat difficult system of improving the Lower Ohio may be advisable. Riprap dams at nearly all the points built in the Lower Ohio, during Captain Shreeve's time, are so much buried under the sand occasionally, that their effect on the navigation is sometimes the reverse of an improvement. The sand washing a channel occasionally over them, leaving the channel obstructed. At Flint Island, however, there is no sand, and the dams there could be repaired with advantage to the navigation of that place. At other points the occasional removal of the sand and obstructions, as logs, trees, &c., which cause it to settle in the channel will do much good. A system of lights for the improvement of the navigation at the Grand Chain, and erection of land marks at a few other points, is earnestly desired by river men. More specific recommendations will be made from time to time as the circumstances of the case will allow.

The sums named below represent the amount which could be profitably expended during another season of active operations:

Miles from Pittsburg.	Name of place.	Amount.
	For improvements above Louisville—	
232	Letart's Island	$6,000
240	Wolf Bar	2,000
255	Eight-mile Island	5,000
273	Raccoon Island	6,000
285	Little Guyandotte River	5,000
290	Grelbottom Ripple	2,500
303	Guyandotte Bar	11,000
312	Burlington Bar	10,000
322	Roag's Shoals, above for 25 miles, and below for 25 miles, rock, &c	17,000
379	Quick's Run Bar	11,000
384	Brush Creek Island	12,000

Estimated amounts required for improving specified points on the Ohio River, &c.—Continued.

Miles from Pittsburg.	Name of place.	Amount.
392	Manchester Island	$14,000
411	Charleston Bar	11,000
425	Augusta Bar	13,000
431	Snag Bar	8,000
456	Four-mile Creek Bar	11,000
471	McCollom's Bar	2,000
509	Gunpowder Bar	18,000
537	Craig's Bar	14,000
		178,500
	Improvements below Lousville—	
	Riprap dams, dredging, removal of obstructions, erection of landmarks, lights, &c	175,000
	Add 10 per cent. for contingencies	35,350
	Total	388,850

REMOVING OBSTRUCTIONS.

In last annual report it was stated that Captain John Rogers, with the steamer Greenback, two crane-boats and flats, had commenced the work of removing obstructions, and that two others with similar outfits were getting ready. The following summary of operation of the three steamers is taken from the monthly reports to the department from the office, for the month of November, 1868. (See pages Nos. 20, 21, 22 and 23.) From considerations of economy, it was recommended to the department that this season but one crane-boat be furnished with each steamer, and that but two steamers be employed, both to work above Louisville. Contracts were, with the advice of the department, accordingly made with John Rogers, with the Greenback, one crane-boat, two flats, and six workingmen, at $72 per day, and Captain Spencer, of the Zebra, with a like outfit. The Greenback began operations July 29; the work being under the superintendence of Captain John Shouse, United States inspector; the district assigned this steamer is between Portsmouth and Cincinnati, with orders to remove wrecks at Steubenville Bridge on her way. The Zebra started out August 10, to work between Cincinnati and Louisville, under Captain D. M. Dryden, United States inspector. This river runs through several collection districts. The amount of revenue collected at the several ports of entry located on it during the fiscal year ending June 30, 1869, could not be ascertained in time. The commerce and navigation of the Mississippi River and all of its branches would be benefited by the improvement of the Ohio River.

Abstract of bids received and opened at 6 p. m., Monday, August 17, 1868.

Number.	Place.	Name.	Cubic yards.	Delivered on river bank key.	Amount.	Boating into dam, per cubic yard.	Amount.	River excavation, per cubic yard.	Amount.	No. of cubic yards, river excavation.
1	White's Ripple	Routh & Watts	2,700	$1 25	$3,375 00	$0 75	$2,025 00			
3	do	Henry & Cook	2,700	1 20	3,240 00	1 20	3,240 00	$1 85	$2,125 00	2,500
4	do	Alonzo Tripp	2,700	2 10	5,670 00	60	1,620 00			
6	do	Manfull, Keith & Co.	2,700	1 15	3,105 00	1 85	3,995 00	1 50	3,750 00	2,500
[illegible]	do	Moor & Chambers						4 00	10,000 00	2,500

Abstract of bids received and opened, &c.—Continued.

Number.	Place.	Name.	Cubic yards.	Delivered on river bank, per cub. yd.	Amount.	Boating into dam, per cubic yard.	Amount.	River excavation, per cubic yard.	Amount.	No. of cubic yards, river excavation.
8	White's Ripple	B. L. Wood, jr						$1 00	$2,500 00	2,500
9	do	Charles Cable	2,700	$1 25	$3,375 00	$0 95	$2,495 00	1 20	3,000 00	2,500
10	do	Henry Baker	2,700	1 50	4,050 00	75	2,025 00	1 25	3,125 00	2,500
11	do	Henry Kelley	2,700	1 75	4,725 00	50	1,350 00	1 25	3,125 00	2,500
12	do	Jacob Cable	2,700	1 50	4,050 00	80	2,160 00	1 20	3,000 00	2,500
13	do	T. J. Power, jr	2,700	1 40	3,780 00	70	1,890 00	1 25	3,125 00	2,500
14	do	J. J. Power	2,700	2 50	5,400 00	1 00	2,700 00	1 00	2,500 00	2,500
15	do	Robert Swan, jr	2,700	1 50	4,050 00	70	1,890 00	1 10	2,750 00	2,500
17	do	James Kerr	2,700	1 30	3,410 00	2 25	6,075 00	80	2,000 00	2,500
19	do	J. B. O'Neil	2,700	1 60	4,320 00	1 75	4,725 00	1 00	2,500 00	2,500
1	Twin Island	Routh & Watts	1,650	1 25	2,062 50	75	1,237 50			
3	do	Henry & Cook	1,650	1 25	2,062 50	1 00	1,650 00			
4	do	Alonzo Tripp	1,650	2 00	3,300 00	45	742 50			
6	do	Manfull, Keiff & Co	1,650	1 10	1,815 00	1 30	2,145 00			
9	do	Charles Cable	1,650	1 00	1,650 00	40	660 00			
10	do	Henry Baker	1,650	1 60	2,640 00	60	990 00			
11	do	Henry Kelley	1,650	1 50	2,475 00	25	412 50			
12	do	Jacob Cable	1,650	1 60	2,640 00	40	660 00			
13	do	T. J. Power, jr	1,650	1 40	2,475 00	75	1,237 50			
15	do	Robert Swan, jr	1,65	1 35	2,227 50	25	412 50			
16	do	Myers & Kerr	1,650	1 10	1,815 00	1 25	2,062 50			
17	do	James Kerr	1,650	1 00	1,650 00	1 40	2,310 00			
1	Captina Island	Routh & Watts	550	1 50	825 00	1 00	550 00			
3	do	Henry & Cook	550	1 30	715 00	1 25	687 50	75	375 00	500
4	do	Alonzo Tripp	550	2 50	1,375 00	50	275 00			
6	do	Manfull, Kief & Co	550	1 15	632 50	1 45	797 50	1 50	750 00	500
7	do	Moor & Chambers						5 00	2,500 00	500
8	do	B. L. Wood, jr						1 50	750 00	500
16	do	Myers & Kerr	500	1 10	605 00	1 25	687 00	75	375 00	500
17	do	James Kerr	500	1 00	500 00	1 50	825 00	75	375 00	500
18	do	Thomas J. Power	500	1 60	880 00	1 00	530 00	1 75	850 00	500
1	Fish Creek	Routh & Watts	400	1 50	600 00	1 00	400 00			
3	do	Henry & Cook	400	1 32	528 00	1 42	568 00			
4	do	Alonzo Tripp	400	2 50	1,000 00	50	200 00			
16	do	Myers & Kerr	400	1 10	440 00	1 35	540 00			
17	do	James Kerr	400	1 13	452 00	1 47	588 00			
18	do	Thomas J. Power	400	1 80	720 00	1 00	400 00			
1	Blennerhassett's	Routh & Watts	1,000	1 25	1,250 00	75	750 00			
3	do	Henry & Cook	1,000	1 28	1,280 00	1 50	1,500 00			
5	do	C. M. Cole	1,000	1 10	1,100 00	75	750 00			
6	do	Manfull, Kief & Co	1,000	1 15	1,150 00	1 10	1,100 00			
9	do	Charles Cable	1,000	1 20	1,200 00	25	250 00			
10	do	Henry Baker	1,000	1 80	1,800 00	40	400 00			
11	do	Henry Kelley	1,000	1 00	1,000 00	25	250 00			
12	do	Jacob Cable	1,000	1 00	1,000 00	40	400 00			
13	do	Thomas J. Power, jr	1,000	1 00	1,000 00	40	400 00			
14	do	J. J. Power	1,000	1 50	1,500 00	1 00	1,000 00			
15	do	Robert Swan, jr	1,000	1 50	1,500 00	50	500 00			
16	do	Myers & Kerr	1,000	1 20	1,200 00	1 90	1,900 00			
17	do	James Kerr	1,000	1 00	1,000 00	2 25	2,250 00			
1	Buffington Island	Routh & Watts	3,000	1 25	3,750 00	75	2,250 00			
2	do	Price & McGee	3,000	1 50	4,500 00	1 25	3,750 00			
3	do	Henry & Cook	3,000	1 25	3,750 00	1 48	4,440 00	90	900 00	1,000
4	do	Alonzo Tripp	3,000	2 00	6,000 00	50	1,500 00			
5	do	C. M. Cole	3,000	1 00	3,000 00	95	2,850 00			
6	do	Manfull, Keif & Co	3,000	1 00	3,000 00	1 00	3,000 00	1 50	1,500 00	1,000
7	do	Moore & Chambers	3,000					6 00	6,000 00	1,000
8	do	B. L. Wood, jr	3,000					1 50	1,500 00	1,000
9	do	Charles Cable	3,000	1 00	3,000 00	18	540 00	1 30	1,300 00	1,000
10	do	Henry Baker	3,000	1 30	3,900 00	40	1,200 00	1 25	1,250 00	1,000
11	do	Henry Kelley	3,000	1 00	3,000 00	20	600 00	1 20	1,200 00	1,000
12	do	Jacob Cable	3,000	1 00	3,000 00	30	900 00	1 20	1,200 00	1,000
13	do	Thomas J. Power, jr	3,000	1 10	3,300 00	40	1,200 00	1 10	1,100 00	1,000
14	do	J. J. Power	3,000	2 00	6,000 00	75	2,220 00	1 00	1,000 00	1,000
15	do	Robert Swan	3,000	1 75	5,250 00	50	1,500 00	1 00	1,000 00	1,000
16	do	Myers & Kerr	3,000	1 00	3,000 00	1 15	3,450 00			
17	do	James Kerr	3,000	90	2,700 00	1 50	4,500 00	75	750 00	1,000

I certify the above to be a true abstract.

W. MILNOR ROBERTS,

U. S. Civil Engineer, in charge Ohio River Improvements.

Abstract of bids opened Monday, September 28, 1868, at 9 o'clock a. m.

Number.	Place.	Name.	Number of cubic yards.	Price per cubic yard on river bank.	Amount.	Price per cubic yard in dam.	Amount.	River excavation, cubic yards.	Amount per cubic yard.	Amount.
2	Brunot's Island	James Bradley						1,000	$0 90	$900 00
3	do	Robert Swan & Co						1,000	95	950 00
4	do	B. S. Wood, jr						1,000	90	900 00
18	do	W. W. Reid and C. O'Rourke.						1,000	1 10	1,100 00
2	Deadman's Island	James Bradley						4,000	93	3,720 00
3	do	Robert Swan & Co						4,000	95	3,800 00
4	do	B. L. Wood, jr						4,000	85	3,400 00
18	do	W. W. Reid and C. O'Rourke.						4,000	1 10	4,400 00
1	Beaver Shoals	Edward O. Sullivan	3,500	$4 75	$16,625 00			11,000	1 75	19,250 00
2	do	James Bradley	3,500	1 00	3,500 00	$0 55	$1,925 00	11,000	95	10,450 00
3	do	Robert Swan & Co	3,500	1 06	3,710 00	60	2,100 00	11,000	95	10,450 00
4	do	B. L. Wood, jr	3,500					11,000	80	8,800 00
5	do	Routh & Watts	3,500	1 25	4,375 00	50	1,750 50			
6	do	Henry & Cook	3,500	1 10	3,850 00	89	3,115 00	11,000	97	10,670 00
10	do	David Evans	3,500	1 20	4,200 00	65	2,275 00	11,000	1 50	16,500 00
12	do	H. W. Ceeley	3,500	1 45	5,075 00	35	1,225 00	11,000	1 50	16,500 00
13	do	E. M. Power	3,500	1 40	4,900 00	30	1,050 00	11,000	1 75	19,250 00
15	do	Robert Routh	3,500	1 10	3,850 00	60	2,100 00			
16	do	J. J. Power	3,500	1 50	5,250 00	40	1,400 00	11,000	1 60	17,600 00
17	do	Myers & Kerr	3,500	1 10	3,850 00	1 09	3,815 00	11,000	1 20	13,200 00
18	do	W. W. Reid and C. O'Rurke.						11,000	1 10	12,100 00
2	Line Island	James Bradley						500	95	475 00
3	do	Robert Swan & Co						500	1 00	500 00
2	Cable's Eddy	James Bradley						*150	8 60	1,290 00
3	do	Robert Swan & Co							9 00	1,350 00
11	do	James Kerr							3 75	562 50
2	Wheeling Island	James Bradley	6,000	1 20	7,200 00	70	4,200 00			
3	do	Robert Swan & Co	6,000	1 25	7,500 00	75	4,500 00			
5	do	Routh & Watts	6,000	1 25	7,550 00	50	3,000 00			
8	do	W. S. Manfull	6,000	1 10	6,600 00	90	5,400 00			
9	do	Philip Sheele	6,000	3 75	22,500 00					
10	do	David Evans	6,000	1 20	7,200 00	75	4,500 00			
11	do	James Kerr	6,000	1 00	6,000 00	1 75	10,000 00			
12	do	H. W. Seeley	6,000	1 60	9,600 00	50	3,000 00			
13	do	E. M. Power	6,000	1 50	9,000 00	65	3,900 00			
16	do	J. J. Power	6,000	1 60	9,600 00	40	2,400 00			
17	do	Myers & Kerr	6,000	1 00	6,000 00	98	5,880 00			
2	Grandview Shoals	James Bradley	4,800	1 05	5,040 00	40	1,920 00			
3	do	Robert Swan & Co	4,800	1 10	5,280 00	43	2,064 00			
5	do	Routh & Watts	4,800	1 25	6,000 00	50	2,400 00			
7	do	C. M. Cole	4,800	95	4,560 00	50	2,400 00			
8	do	W. S. Manfull	4,800	1 10	5,280 00	90	4,320 00			
10	do	David Evans	4,800	1 20	5,760 00	50	2,400 00			
11	do	James Kerr	4,800	1 00	4,800 00	2 00	9,600 00			
12	do	H. W. Ceeley	4,800	1 45	6,960 00	35	1,680 00			
13	do	E. M. Power	4,800	1 40	6,720 00	35	1,680 00			
14	do	Alonzo Tripp	4,800	1 60	7,680 00	60	2,880 00			
16	do	J. J. Power	4,800	1 40	6,720 00	40	1,920 00			
17	do	Myers & Kerr	4,800	80	3,840 00	98	4,704 00			
2	Sheet's Ripple	James Bradley	4,800	1 05	5,040 00	40	1,920 00			
3	do	Robert Swan & Co	4,800	1 10	5,280 00	43	2,064 00			
5	do	Routh & Watts	4,800	1 25	6,000 00	50	2,400 00			
7	do	C. M. Cole	4,800	95	4,560 00	50	2,400 00			
8	do	W. S. Manfull	4,800	1 10	5,280 00	90	4,320 00			
10	do	David Evans	4,800	55	2,640 00					
11	do	James Kerr	4,800	1 00	4,800 00	2 00	9,600 00			
12	do	H. W. Seeley	4,800	1 45	6,960 00	35	1,680 00			
13	do	E. M. Power	4,800	1 40	6,720 00	30	1,440 00			
14	do	Alonzo Tripp	4,800	1 60	7,680 00	60	2,880 00			
16	do	J. J. Power	4,800	1 40	6,720 00	40	1,720 00			
17	do	Myers & Kerr	4,800	90	4,320 00	88	4,224 00			
2	Rowland's Race	James Bradley						1,200	95	1,140 00
3	do	Robert Swan & Co						1,200	1 00	1,200 00
2	Marietta Island	James Bradley	11,000	1 25	13,750 00	47	5,170 00			
3	do	Robert Swan & Co	11,000	1 30	14,300 00	50	5,500 00			
5	do	Routh & Watts	11,000	1 25	13,750 00	35	3,850 00			
7	do	C. M. Cole	11,000	1 00	11,000 00	75	8,250 00			
8	do	W. S. Manfull	11,000	1 10	12,100 00	90	9,900 00			
10	do	David Evans	11,000	1 20	13,200 00	55	6,050 00			

* Rock.

Abstract of bids opened Monday, September 28, 1868, &c.—Continued.

Number.	Place.	Name.	Number of cubic yards.	Price per cubic yard on river bank.	Amount.	Price per cubic yard in dam.	Amount.	River excavation, cubic yards.	Amount per cubic yard.	Amount.
11	Marietta Island	James Kerr	11,000	$1 00	$11,000 00	$1 98	21,780 00			
12	do	H. W. Seeley	11,000	1 60	17,500 00	50	5,500 00			
13	do	E. M. Power	11,000	1 60	17,600 00	55	6,050 50			
16	do	J. J. Power	11,000	1 55	17,050 00	40	4,400 00			
17	do	Myers & Kerr	11,000	1 05	11,550 00	1 00	11,000 00			
2	Mustapha Island	James Bradley						*50	$8 60	$1,290 00
3	do	Robert Swan & Co						*50	9 00	1,350 00
7	do	C. M. Cole						*50	4 00	600 00
2	Belleville Island	James Bradley	3,500	1 05	3,675 00	40	1,400 00			
3	do	Robert Swan & Co	3,500	1 10	3,850 00	43	1,505 09			
5	do	Routh & Watts	3,500	1 25	4,375 00	50	1,750 00			
6	do	Henry & Cook	3,500	1 15	4,025 00	87	3,045 00			
7	do	C. M. Cole	3,500	95	3,325 00	40	1,400 00			
8	do	W. S. Manfull	3,500	1 10	3,850 00	90	3,150 00			
10	do	David Evans	3,500	1 25	4,375 00	95	3,325 00			
11	do	James Kerr	3,500	1 00	3,500 00	2 10	7,350 00			
12	do	H. W. Seeley	3,500	1 35	4,625 00	50	1,750 00			
13	do	E. M. Power	3,500	1 55	4,425 00	40	1,400 00			
16	do	J. J. Power	3,500	1 40	4,900 00	40	1,400 00			
17	do	Myers & Kerr	3,500	95	3,325 00	93	3,255 00			

* Rock.

Abstract of bids awarded from the following abstract.

Place.	Name.	Number of cubic yards.	Price of cubic yard delivered on river bank.	Amount.	Price per cubic yard in dam.	Amount.	Number of cubic yards, river excavation.	Price per cubic yard.	Amount.
White's Ripple	Routh & Watts	2,700	$1 25	$3,375 00	$0 75	$2,025 00			
Do	B. L. Wood, jr						2,500	$1 00	$2,500 00
Twin Island	Thomas J. Power, jr.	1,650	1 40	2,310 00	40	660 00			
Captina Island	Myers & Kerr	550	1 10	605 00	1 25	687 00	500	75	375 00
Fish Creek	do	400	1 10	440 00	1 35	540 00			
Blennerhassett's Island	C. M. Cole	1,000	1 00	1,000 00	25	250 00			
Buffington Island	Henry Baker	3,000	1 30	3,900 00	40	1,200 00			
Do	J. J. Power						1,000	1 00	1,000 00

I certify the above to be a true abstract.

W. MILNOR ROBERTS,
U. S. Civil Engineer, in charge Ohio River Improvements.

Abstract of bids awarded from the foregoing abstracts.

Number.	Place.	Name.	Number of cubic yards.	Price per cubic yard delivered on river bank.	Amount.	Price per cubic yard loaded into dam.	Amount.	Number of cubic yards, river excavation.	Price per cubic yard.	Amount.
4	Brunot's Island....	B. S. Wood, jr	......	......	......	......	......	1,000	$0 90	$900 00
4	Deadman's Island	......do	......	......	......	......	......	4,000	85	3,400 00
2	Beaver Shoals.....	James Bradley	3,500	$1 00	$3,500 00	$0 55	$1,925 00	......	......	......
4	......do	B. L. Wood, jr	......	......	......	......	......	11,000	80	8,800 00
11	Cable's Eddy......	James Kerr ..	......	......	......	......	......	*150	3 75	562 00
5	Wheeling Island ..	Routh & Watts	6,000	1 25	7,550 00	50	3,000 00	......	......	......
2	Grandview Shoals.	James Bradley	4,800	1 05	5,040 00	40	1,920 00	......	......	......
7	Sheet's Ripple.....	C. M. Cole	4,800	95	4,560 00	50	2,400 00	......	......	......
2	Rowland's Race ...	James Bradley......	......	......	......	......	......	1,200	95	1,140 00
5	Marietta Island ...	Routh & Watts	11,000	1 25	13,750 00	35	3,850 00	......	......	......
7	Mustapha Island ..	C. M. Cole	......	......	......	......	......	*150	4 00	600 00
7	Belleville Island...	......do	3,500	95	3,325 00	40	1,400 00	......	......	......

* Rock.

Abstract of bids opened June 16, 1869, at 6 o'clock p. m., for removing obstructions from Ohio River.

No.	Name.	Amount.	Name of steamer.
1	C. M. Cole....................................	$65,00	Zebra.
2	C. M. Cole....................................	72,00	Oil City.
2	James Routh....................................	75,00	
3	John Rodgers....................................	88,00	Greenback.
4	Louis F. L. Vandergrift....................................	124,00	

I certify the above to be a true abstract.

W. MILNOR ROBERTS,
U. S. Civil Engineer, in charge Ohio River Improvements.

Abstract of bids awarded from the above.

No.	Name.	Amount.	Name of steamer.
1	C. M. Cole....................................	$62,00	Zebra.
3	John Rodgers	72,00	Greenback.

SNAG-BOAT OPERATIONS 1868.

Operations of the wrecking steamer Greenback, Captain John Rodgers, contractor, under Captain John Shouse, United States inspector.—The Greenback began work June 5, at a sunken canal-boat loaded with clinkers, at Brunot's Island, which was removed. The river was too high from the 8th to the 12th of June; at the latter date work was commenced at two sunken coal-boats in the channel at Jack's Run, five miles from Pittsburg. June 25, finished at Jack's Run and proceeded to Steubenville railroad bridge, 68 miles below Pittsburg; raised one snag on the way; worked at several wrecks there until July 2. They also took out some rocks under the bridge which interfered with the navigation. July 6, left Steubenville and proceeded to Wheeling, raising a sunken flat-boat the same day. July 8, raised sunken coal-barge at Sunfish, 24 miles below Wheeling. July 10, working at a sunken

coal-boat at Williamson's Island, 138 miles below Pittsburg; a brick-boat at Blannerhassett's Island, 183 miles below Pittsburg; detained there from July 15 to 22. At Belleville Island, July 23, 202 miles from Pittsburg, they encountered a strongly-framed model barge, which gave them a great deal of trouble, the work being interfered with by high water and the passage of numerous tow-boats; the tow of one of these boats broke loose above them and set the snag-fleet adrift, compelling them to lose their hold of a partially-raised wreck, which again sunk. Leaving Belleville, August 11, they next proceeded to Buffington Island, 214 miles below Pittsburg, where they were several days engaged raising a boat, loaded with boulders. September 1, at Guyandotte, they were working at a drift pile, which they burnt and tore up completely; it was very much in the way of ascending boats of all kinds. The rise in the river, September 10, caught them at Portsmouth, 370 miles below Pittsburg. Waiting until October 3, the river showing no signs of falling to a reasonable working stage, the Greenback was ordered to return to Pittsburg. On the trip down, from June 5 to September 10, they raised in all fifteen wrecks, and removed, besides drift and several small snags, 85 large snags, four stumps, and nineteen logs; also several rocks, and cut down a number of trees likely to become snags. After her return to Pittsburg, the river having again fallen, Mr. Roberts dispatched the Greenback down again with one crane-boat and a half crew to work at a number of snags, &c., which had been reported to this office, and removed such other obstructions as they might find in the way. They left Pittsburg October 21, the marks showing but two feet of water; and, the water being clear, they were able to see everywhere anything at all dangerous in the way of snags, wrecks, &c. Having no extra boats with them, they got along rapidly, reaching Portsmouth, where they had left off before, November 3, where another rise overtook them. On the way down they removed 41 snags and one stump, besides cutting off three trees. The steamer left Portsmouth upward-bound November 4, and reached Pittsburg November 16, where she laid up finally for the winter.

Operations of the wrecking steamer Zebra, contractors Cole and Spencer, under B. J. Caffrey, United States inspector.—The Zebra began at Cincinnati, Ohio, July 21, and made fair progress, removing troublesome logs and snags in that vicinity, until she came to pieces of wrecks, being steamers Magnolia and Wild Hoosier, pieces of which were strewn about in a number of places for several miles. From the 5th to the 10th, on account of high water, the inspector laid the boat up. On August 15 she succeeded in getting out most of the wreck of the Magnolia. By the evening of the 19th they had moved the wreck of the Hoosier sufficiently away from the channel. August 29 the party were working at the bow of the Magnolia, which, after her explosion, had drifted down to North Bend, fifteen miles below Cincinnati. Being heavily plated and bolted with iron, and firmly imbedded in the sand, it gave a great deal of trouble. They used fires to burn up those parts standing out of water. September 12, the river rising rapidly, the work stopped, and there being no prospect of its soon falling, October 2, the inspector was ordered to cease work. The Zebra cleared out the river from Cincinnati to Aurora, Indiana, a distance of twenty-six miles, removing seven wrecks, twenty large snags, with several smaller ones, and four troublesome logs.

Operations of the snag-boat Petrolia, Captain James Routh, contractor D. M. Dryden.—The Petrolia began work at Evansville, Indiana, about 770 miles below Pittsburg, July 27. The work assigned her was mostly

upon the removal of snags, which are large and much more numerous in the Lower Ohio regions than they are above. By the end of July the Petrolia had moved down thirty-four miles, having in the mean time removed sixteen snags, some of which were quite large. From the 1st to the 15th of August they had removed twenty-seven snags in ninety-eight miles, (inspector's estimate of distance.) The river being rather high, some snags, troublesome to low-water navigation, could not be found; these they intended to remove on their return up the river. From August 15 to August 25 the boat was laid up, on account of high water at Paducah, mouth of the Tennessee River. Returning upward from Paducah August 25, they removed twenty snags in the distance of twelve miles, by the end of the month. By the middle of September they had moved up thirty-one miles, to Hurricane Island, removing thirty-six snags. Writing from Hurricane Island, under date of September 13, the inspector says: "We arrived at this place in good season. There are one hundred snags in the water here, all with their ends in sight above water; they are deeply imbedded in the sand and mud; unfortunately the river is raising again, there being six feet on Walker's Bar, five miles above here, and we may not be able to reach all. We will take out fifty of the worst snags here, and cut them up on the river bank, if the water permits. The snags are all very heavy, and have to be cut up into short pieces and taken to the bank, or, when convenient, dropped into deep holes out of the way. The average size of the snags is from 2½ to 5 feet through at the butt, and from 6 to 120 feet in length, and are mostly tough wood, consisting in the greater part of oak, sycamore, pecan, elm, and cottonwood; some of them require both crane-boats to raise them. One that we took out, a monster pecan, was 5 feet in diameter and 120 feet in length. We worked at this snag four days, it being solid as mahogany, breaking chains and wearing out saws, but we succeeded in getting entirely rid of it. The river having raised to 30 feet in the channel, the Petrolia left Hurricane Island September 29, reaching Evansville, Indiana, October 1; and October 2 Mr. Roberts telegraphed the inspector to quit working for the season. From Evansville, Indiana, to Paducah, Kentucky, a distance of 136 miles, between July 27 and September 15, the Petrolia removed 99 snags, besides cutting down a large number of over-hanging trees, likely to become snags.

Summary of snag-boat's operation on the Ohio River, 1868.

Steamers.	At work between—	Distance in miles.	Wrecks.	Snags.	Stumps.	Logs.
Greenback	Pittsburg, Pa., to Portsmouth	370	15	126	5	19
Zebra	Cincinnati to Aurora	26	7	20	......	4
Petrolia	Evansville, Ind., Paducah, Ky	136	......	99	......	......
Total		532	22	245	5	23

There are still remaining 435 miles of the river to be worked upon, and several points included in that already worked over omitted on account of high water.

Respectfully submitted.

THOMAS P. ROBERTS,
Assistant United States Civil Engineer.

Bvt. Maj. Gen. G. WEITZEL,
Major of Engineers United States Army,
In temporary charge Ohio River Improvement, Louisville, Ky.

N 1.

OFFICE OF OHIO RIVER IMPROVEMENTS,
Pittsburg, February 12, 1869.

GENERAL: In obedience to instructions from Headquarters Engineer Corps, dated October 21, 1868, I respectfully submit the following special report on the subject of the improvement of the Ohio River at Wheeling Island. In 1868, at the date of September 9, I had the honor to recommend, among other improvements along the river, the construction of a riprap dam at the head of Wheeling Island, designed to improve the water in the channel generally used, on the left or Virginia side of the river, which it was proposed to do by closing the channel at the head of the right or Ohio chute, by a low dam, which, at moderate stages, would throw nearly all the water to the Virginia channel. This plan was approved and proposals were received for furnishing and putting in the riprap stone, and the contract was awarded October 10, 1868.

About the same time that proposals were being received, a number of the citizens of Bridgeport remonstrated against the building of a dam on the Ohio side. A committee of gentlemen interested in Bridgeport and vicinity called at the United States engineer's office, in Pittsburg, and stated their views, referring at the same time to the interests which they believed would be seriously affected by the construction of the proposed dam. This led to my letter to the Engineer Department, dated October 16, 1868, and to the letter of instructions to me, dated October 21, 1868, requiring a special report on the subject. Meanwhile no work, excepting the quarrying of stone, (which could, if deemed advisable, be made applicable at some other point on the river,) was undertaken at that place; the lateness of the season rendering this circumstance of comparatively little consequence. At favorable periods since, I have had careful examinations and additional surveys, and an elaborate chart of the place made from the new surveys, drawn on a scale of five hundred feet to an inch, which chart accompanies this report.

These examinations and surveys were made by Mr. Thomas P. Roberts, assistant United States civil engineer, assisted by Captain George W. Rowley, United States consulting pilot, with the party belonging to the government inspection steamer "Tidioute." The reports made to me from time to time, aided by my personal familiarity with the locality, have enabled me to understand the case thoroughly, and my views on the subject may be briefly expressed.

There can be no doubt that, if no private interests were to be affected or considered, the proper mode for improving navigation at Wheeling Island would be to throw the dam across the Ohio chute, as proposed.

There are, however, some private interests which may be injured thereby, although, in my opinion, the injury will be much less than has been anticipated and stated by the parties interested on the Ohio side, residing in and near Bridgeport.

The accompanying chart is so complete in itself that it may be referred to as part of this report, and as a means of shortening it.

Owing to the existence of a low bridge, with piers about two hundred feet apart, running from the island to Bridgeport, which has existed for many years—long before the erection of the suspension bridge over the main channel on the Wheeling side—the navigation in the Ohio chute may be regarded as entirely of a local character, which is only used locally for the passage of rafts and flats, &c., and which cannot be navigated by the ordinary steamers, coal fleets, &c., running the main river,

because in very low water they could not run there, and in higher stages they could not pass under the low bridge.

By reference to the chart it will be seen that on the Ohio side above the proposed dam no injury will accrue; on the contrary, the ferry there will be improved by getting an increased depth of water, which the back water of the dam will give.

Whatever injury there might be would, therefore, occur below the dam, to interests along the Ohio shore, and it would be mainly confined to those above the low bridge. The nail-keg factory, and the coal shipping tipple, are the two most materially interested. Their positions are shown on the map, above the bridge.

It is true that log rafts and other rafts for local consumption at the saw-mill on (Ohio) Wheeling Creek, below the bridge, and in Bridgeport and its vicinity, can now run down the Ohio chute at a certain stage, say about three to five feet of water, which they could not do after the completion of the dam, excepting at a six feet stage, (or any greater depth,) which would enable them to pass over the low dam. But at nearly all times when such log rafts or other rafts can now safely pass down the Ohio chute, they could be towed up from the lower end of the same chute as far as the low bridge. It is thus far optional. In low water there is no navigation through that chute.

As a substitute for the proposed dam, it has been suggested that dredging of the bars in the Virginia channel, on the city of Wheeling side, would sufficiently improve the main channel of the river, without interfering with the private interests along the Ohio chute on the Bridgeport side.

Doubtless the channel can be improved by dredging the gravel bars as indicated. There exists, however, a special objection to any considerable extent of dredging at the upper end of the main chute. Burlington Bar, only one and one-half miles above, (see Captain Sanders's chart, sheet No. 12,) is a troublesome place now, and if the channel at the head of Wheeling Island is dredged low enough to draw the whole flow into that side, it will necessarily reduce the surface of the pool between Wheeling Island and Burlington Ripple, and increase the low water difficulty at the latter point. Dredging at the head of any bar on a descending stream must, inevitably, in the nature of the case, lower the surface of the immediately adjoining pool above.

One of the reasons assigned by Captain Sanders, and I believe sustained by Captain Hughes, both of the United States Engineer Corps, was that a dam at the head of Wheeling Island would raise the pool above, and consequently benefit the shoal navigation at Burlington Ripple shoal.

The examining engineer party, in the autumn of 1868, gauged the flow of water in both chutes, and found in the Ohio chute, passing per minute, forty-three thousand cubic feet, and in the main or Virginia chute, one hundred and thirty-seven thousand cubic feet, an aggregate of one hundred and eighty thousand cubic feet, at that time, which was called a fourteen-inch stage; the lowest water of the year, but not so low as it has occasionally been.

A riprap wing dam had been proposed or suggested by Captain Sanders at Burlington Ripple, unless the completion of the proposed dam at Wheeling Island should render it unnecessary. The same may be said now. If the channel at Wheeling Island be improved solely by dredging, without a dam on either chute to concentrate the water, it will be necessary to construct a dam at Burlington Ripple; otherwise the expenditure at Wheeling Island might be worse than useless to the main

navigation of the river, and be only a partial local advantage to the city of Wheeling for its low-water river trade below the city, though at the same time injuring its own low-water trade above—to Steubenville, to the Erie Canal at Beaver, and to Pittsburg, &c. It would be literally robbing Peter to pay Paul, with profit to no interest, private or public.

I could not, therefore, recommend the abandonment of the proposed dam at the head of the Ohio chute, and the dredging at the head in the Virginia chute, without at the same time recommending work to be done at Burlington Ripple.

I am well aware that the Engineer Department entertains only the desire to improve the navigation at the least practicable cost, and so as to be productive of the greatest benefit to the general public, with no wish to interfere unnecessarily with any private local interests, but, on the contrary, to help them so far as it may be consistent with the predominant interests of the river commerce. Here is a case where these two come somewhat in conflict, and it is rather a delicate task to decide to what extent either or both should be compromised. Being familiar with the details and surroundings on the ground, I am naturally expected to make up a decision or special recommendation of some sort for your consideration.

Before doing this, it may be proper to advert to the several duties which have been devolved upon me, as an engineer acting under your instructions, and referring to some of the general circumstances which belong to the consideration of the subject, and which may have a bearing on the present decision. Three distinct or different duties have been ordered: first, the general survey, involving a full general report and maps of the entire nine hundred and sixty-seven miles in length; (of which two hundred and seventy-one miles were surveyed by Major Sanders;) second, the removal of all movable obstructions along the whole length; third, the locaton and construction of riprap dams, excavation of channels, &c., chiefly for the improvement of the low-water navigation at the points where most needed.

The surveys of the river may be regarded as preliminary to the thorough consideration of the several plans which have been proposed for the radical improvement of the Ohio. These surveys are now substantially completed; only a few soundings, and perhaps a week or ten days of levelling at certain points on the upper two hundred and seventy-one miles, or the portion surveyed many years ago, remain to finish the necessary field data. Without now referring to any particular plan for the radical improvement of the river, it is known that on any plan or combination of plans the cost will be a number of millions of dollars. No appropriations looking to such an expenditure or such radical improvement have yet been made by Congress, excepting the small amount applied to surveys, which of course appertains to any and to all of the improvements of the navigation in the past, and for the future.

Meanwhile, during the progress of these surveys in 1867 and 1868, in their low-water periods, we have been engaged in removing snags, logs, sunken boats, wrecks of steamers, &c., thus clearing a large portion of the river from the same, and to that extent rendering the navigation more safe. And during the same season we have prosecuted those minor improvements along the stream, designed chiefly to improve the low-water navigation and incidentally to make it better and safer for coal-fleets, steamers, &c.

The appropriations being comparatively small, we were obliged to make the best distribution of the fund that the circumstances would allow. Thus last year's appropriation for the entire Ohio River, for the

three purposes named, was only eighty-five thousand dollars. If, therefore, we had attempted to apply a little of this sum to every point on the river where improvements are practicable, it would have been all frittered away without the accomplishment of any practical good; hence, it was suggested that the balance, not applicable to "surveys," and "removing obstructions," should be divided at a few points on the Upper Ohio, where the navigation suffered most from shoals during the low-water periods. Wheeling Island, Marietta Island, and other points, heretofore made known to you, were found to be worse than many other places, some of which had already been improved by the government, and they were accordingly designated as points deserving immediate attention on that account, and work was advertised and let.

This brings me to the point I desire to present. If the government were prepared to enter immediately upon the construction of works for the radical permanent improvement of the entire river, any material expenditures for the minor improvement of the navigation at Wheeling Island might be indefinitely deferred.

On the other hand, if it could be known that the river would never receive such radical improvement, the greater would be the necessity for prosecuting the minor improvements, including such works as may, under all the circumstances, be deemed best at Wheeling Island.

Hitherto, as you are aware, appropriations toward the improvement of the Ohio River, compared with other national expenditures, have been quite limited, so that the fund, when divided between the surveys, the removing of obstructions, and actual works of improvements, has not been sufficient to warrant the commencement of works excepting at a comparatively few places, as already indicated.

Thus the process is slow, and on this system the improvement of the river, even by the present mode, would occupy a number of years. We asked for larger appropriations than have heretofore been made, in the hope of pushing forward the most needed works simultaneously at all points along the whole river; but Congress has reduced those amounts so materially that we have been obliged to confine our operations to suit the small sums appropriated, and to go on only with the worst places, as they show themselves.

For the reasons included above, it might be deemed expedient at this time to modify the plans so far as they may properly admit of it, at those points where the proposed works appear to bear hard upon important private interests.

In the case of Wheeling Island, however, if the private interests on the Virginia side to be benefited by the proposed dam were to be compared with the private interests claimed to be injured on the Ohio side, they would appear to be the greater of the two, irrespective of the general advantage to the public to be derived from the improvement of the navigation. I do not refer to these for the purpose of presenting an argument in favor of overriding or overlooking the private interests on the Ohio side, but merely as one of the facts belonging to the case. The people of Wheeling, so far as I know, have taken no part in any controversy concerning the proposed dam. Yet they are materially interested in the improvement of the main channel adjacent to that city, both immediately above and below it. In low or moderate stages of the water regular daily steam packets ply between Wheeling and the cities below and above. There is a tri-weekly line to Cincinnati; daily line to Parkersburg, and another to Sunfish, &c., below Wheeling; and to Pittsburg and Steubenville, above, two daily lines; the business of which in low water is now of course regulated during the low-water periods

by the shoalest places they are compelled to pass. Thus a steamer or a barge having an average bearing in the water of 150 by 30 feet, carries 140 tons for every foot of depth she displaces, and an improvement of even 6 inches in the channel depth enables her to carry 70 tons more freight. The advantage of being able to ship even 70 tons more freight on each barge or steamer becomes important when continued through several months of low water; to a city situated as Wheeling is. It is true that the people generally do not pay attention to these points. Yet they are not the less interested. Even the river men themselves are not in the habit of close investigation of the subject, yet it is true that an improvement of one foot in depth along the Ohio navigation is a matter of very great importance, involving material benefit to the commerce of the country, far beyond the sums expended in accomplishing it.

I have recommended the construction of a low dam across the Ohio chute at the head of Wheeling Island, believing that to be the best method of improving the navigation over the shoal places in the main or only channel that is run by river men; but, viewing all the circumstances, my opinion is that for the present it may answer to combine with the erection of a still lower dam dredging of the bars, so as not to reduce the depth, but rather to increase it in the pool at the head of the island.

In order to carry this plan out judiciously and economically there should be some discretion to be exercised respecting the quantity of stone to be put in at the head of the island, and the quantity of dredging to be done in the channel.

The estimated quantity required in the dam, and for which a contract exists, is 6,000 cubic yards. A less quantity, say not exceeding 4,000 cubic yards, might be applied to a dam at the head of the island, arranged to suit the case; and dredging, say to the amount of 4,000 cubic yards, made in the channel.

Upon the effect of this work would depend, to some extent, the amount of work required to perfect the channel at Burlington bar, above.

Under the circumstances I think it would be justifiable to authorize the distribution of the 6,000 cubic yards of stone between the two points, namely, the Ohio chute at the head of Wheeling Island, and at Burlington bar, to be arranged to suit the case, with authority to dredge to the extent of not exceeding 4,000 cubic yards in the main channel, on the Virginia side of Wheeling Island.

I think it probable that in this way we may improve these two places without materially injuring any private interests, and without extra cost to the government, bringing them on a par with other points which have already been improved. Coupled with the authority to dredge, and keeping in mind the intimate relation between Burlington bar at the head, and Wheeling Island at the foot of the same point, it would be advantageous to the government if some discretionary power could be given in arranging the amount of riprap and dredging, respectively, at both, to be exercised during the progress of the work.

Very respectfully, your obedient servant,

W. MILNOR ROBERTS,
U. S. Civil Engineer, in charge Ohio River Improvement.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army,
Headquarters Corps of Engineers, Washington, D. C.

N 2.

OFFICE OHIO RIVER IMPROVEMENT,
Pittsburg, Pa., February 15, 1869.

GENERAL: In obedience to instructions from Headquarters Engineer Corps, dated October 21, 1868, I respectfully submit the following special report on the subject of the improvement of the Ohio River at Marietta Island. In 1868, at the date of September 9, I had the honor to recommend, among other improvements along the river, the construction of a riprap dam across the Ohio chute at the head of Marietta Island, for the purpose of increasing the depth of water in the main channel, on the Virginia side. Citizens of Marietta having remonstrated against the erection of the dam as proposed at that place, I have, in accordance with my instructions, deferred putting any stone in that part of the river.

The circumstances which led to the present report will more fully appear by referring to letters from this office dated October 16, 1868. Accompanying this report is a chart constructed from new surveys made by Mr. Thomas P. Roberts, assistant United States civil engineer, assisted by Captain George W. Rowley, United States consulting pilot. Proposals were received for furnishing and putting in the riprap stone, and the contract was awarded September 28, 1868.

No work has been authorized excepting quarrying stone, which can be made applicable, in whole or in part, to other points, and especially to Carpenter Bar, if required.

The chart shows very clearly the main features of the case, and will be useful in the determination of the question respecting the proper course to be adopted.

The case is very similar to that at Wheeling Island; at least to a sufficient extent to warrant particular reference to my special report on the proposed improvement at Wheeling Island, dated February 12, 1869, as containing certain general views equally applicable to Marietta Island. In one important respect, the two places are of the same nature; for there is no doubt that, independently of interest at the city of Marietta, the proper method of improving the low-water navigation here is by throwing a riprap dam to turn the water at a three-feet stage (or not exceeding four feet) into the main channel on the left, or Virginia, chute. The fact that no tributary streams of consequence enter on the Virginia side, and that the Little Muskingum River, Duck Creek, (a considerable stream,) and the Big Muskingum River on the Ohio side, in times of freshets contribute large amounts of drift and sand to obstruct the channel, points clearly to the Virginia chute as the natural and best channel, especially in coal-boat stages, when there may be eight or ten feet water in the channel.

But the people of Marietta remonstrate against the building of the proposed dam across the head of the Ohio chute, claiming that it will seriously injure their harbor, and the general interests of the city.

It may be true that a dam put across the Virginia chute, by throwing all the water of the river at and below a four-feet stage into the Ohio chute, would improve the navigation on the Ohio side, and that possibly it might help the harbor at Marietta, to a certain extent; though it is obvious that it would at the same time destroy the low-water channel on the Virginia side, which, for the reason already assigned, may properly be regarded as the main channel of the Ohio River. My judgment, therefore, is decisively adverse to closing the Virginia chute, and in favor of closing the Ohio chute, to the extent indicated, if a dam is to be built across either chute.

The plan of improvement to be carried out at Marietta Island will, to some extent, affect the proposed work for the improvement of the navigation at Carpenter's Bar, one and a half mile above. As suggested by Captain Sanders and Captain Hughes many years ago, the raising of the pool above Marietta Island by means of a dam across one of the chutes, will have the effect of deepening and improving the water at Carpenter's Bar; and owing to the shape of the stream, it is believed that a dam on the Ohio chute would have a better effect, in this respect, than if it were on the Virginia chute.

VIRGINIA CHUTE.

The usual, and ordinarily the best channel is now down the left or Virginia chute. It is shorter, broader, and of the two the more natural. The shoals which now impede navigation on the left chute occur at two points, above Davis's Run, and at Sutton's Run, near each other, at the head of the chute. The bottom is gravel, exempt from sand fillings, such as exist along the Ohio chute, and snags, &c., do not settle in it as they do in the Ohio chute.

OHIO CHUTE.

For the first half mile, from the head down, this chute is the deeper of the two; but snags, &c., thrown out from the Little Muskingum River, which enters above the island, often render the navigation dangerous on that account.

At the end of the first half mile begin the sand-bars, of a shifting, changeable nature, which take off from one foot to two feet or more of the navigable depth elsewhere available at about an eight-feet stage. There have been times, at an eight-feet stage, when boats drawing six feet could not pass Duck Creek. This sand, however, as the river falls, runs off, leaving channels, so that after a long season of what is called "dead low water" this chute sometimes has better water than the other. This occurs, however, when the river trade is also "dead low" or at its minimum, on account of general low water.

Dredging of these sand-bars would be only a temporary remedy, requiring to be repeated after heavy freshets in the Little Muskingum and Duck Creek.

On the Ohio chute, the channel is very crooked at the foot opposite the city of Marietta, just above the mouth of the Big Muskingum. The jetty, built some years ago by the city, from the foot of the island down stream, was intended to increase the depth and improve the channel and the city harbor, and it has no doubt had some effect.

Dredging has also been resorted to at the city expense, and dredging may temporarily improve the navigation in that vicinity. But the operating causes, namely, the general shape of the river, the position of the island and of the city, and the entrance of the three considerable tributaries on that side of the river, may be regarded as permanent, and as always tending during floods to reproduce the same result—sand-bars. My opinion is, therefore, that no work of that character at the lower end of the island, opposite the city of Marietta, can make any permanent material improvement of the general navigation of the Ohio River at Marietta Island, and that consequently it would not be advisable for the government to enter specially upon it. Whatever might be done in that way could only be considered as chiefly a local improvement of the

harbor of Marietta, though incidentally it might temporarily improve the passage for vessels desiring to run the Ohio chute.

The shoals at Marietta Island and at Carpenter's Bar, now afford, in low stages of the river, more than a foot less depth than Petticoat Bar, (one of our improved points, which was formerly much worse,) and nearly a foot less than points *up* to Wheeling Bar, and *down* elsewhere on the river. A large profitable freight business can be done at four feet, while with a foot less, the tonnage carried must be reduced one hundred and forty tons on a boat, displacing one hundred and fifty by thirty feet, as shown in my special report on Wheeling Island.

It is not certain that the construction of a low dam on the Ohio chute at the head of Marietta Island will do any serious injury, or any injury to the river business of Marietta. At low water Marietta is now out of the line of the usual channel for steamers, &c., passing along the river, which do not have occasion to stop at that port; and those which touch that port do so when coming down by, rounding to, and passing around the jetty to the wharf boats; while those which touch on their upward passage pass out to the main channel by the same route, as indicated by the red lines on the chart.

At Harmar, on the opposite side of the mouth of the Big Muskingum River, steamers can always land without difficulty when they can run to Marietta, either from above or from below.

Referring to the general remarks contained in my special report on Wheeling Island, dated February 12, 1869, for views having nearly the same bearing upon this case, I would respectfully suggest that we might test the effect of a very low dam on the Ohio chute at the head of Marietta Island, in combination with a dam at Carpenter's Bar, and a small amount of dredging at each place—that is, in the Virginia chute at Marietta Island and at Carpenter's Bar—without increasing the quantity of stone contracted for, but by the addition of, say, three thousand cubic yards of dredging at Marietta Island and two thousand cubic yards of dredging at Carpenter's Bar.

With a little discretionary power authorized to be exercised at these two points, we may succeed in bringing the low-water navigation here on a par with other places we have improved, without material, if any, injury to private interests. And if the people of Marietta become aware that it is our anxious desire to do nothing that will injure their harbor, they will acquiesce in our plans, and perhaps join with us in executing them.

If some discretionary power at this particular locality (Marietta Island) could be made to cover excavation of sand or gravel, or removal of old riprap material that might be found necessary to perfect the general navigation opposite the city of Marietta, in conjunction with efforts of the citizens toward the improvement of the channel, it might prove to be advantageous both to the people of Marietta and to the general navigation interests.

In regard to stone, quarried and delivered along the river bank, and even after it is put into dams, in case of any radical change hereafter in the system of improvement, the material will be conveniently available on any works where such stone may be required.

The bulk of all the work that has been done in improving the low-water navigation consists of riprap stone, which at a small expense can, whenever it may be necessary, be removed. At present, however, there is no stone quarried, but such as we expect to use during this season.

In conclusion, keeping in view all the circumstances of the localities

of Marietta Island and Carpenter's Bar, I recommend that such discretionary power be given as you may think proper to confer.

Very respectfully, your obedient servant,

W. MILNOR ROBERTS,
U. S. Civil Engineer, in charge Ohio River Improvement.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army,
Headquarters Corps of Engineers, Washington, D. C.

APPENDIX O.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., October 7, 1869.

GENERAL: I have the honor to make the following report of operations on the river improvements under my charge for the year ending June 30, 1869.

PATAPSCO RIVER IMPROVEMENT.

The three dredging machines, the Patapsco, Potomac, and Chesapeake, with their scows, three to each machine, with the steam-tug Robert Leslie to convey the scows to the places of deposit, were engaged from the 1st of July to the 1st of November, 1868, in deepening and widening the new or Craighill channel, principally at its lower end. At this date, on account of rough weather, the dredges were removed to upper entrance of Brewerton, where they were efficiently engaged till the 10th of December, when, on account of the severity of the weather precluding an economical prosecution of the work, they were withdrawn, and, with the scows and tug, placed in a place of security for the winter, and all hands discharged except the master of the tug, retained as superintendent of watchmen, and one watchman for each of the four dredges, including the Susquehanna.

Material removed from the Craighill channel from July 1, cubic yards	76,000
Material removed from Brewerton channel, cubic yards	15,000

Preparatory to the commencement of operations during the present season of 1869, the steam-tug Robert Leslie was repaired in the month of March, and in the month of May the three dredges, the Patapsco, Potomac, and Chesapeake, on account of its decayed, worn-out condition, required its complete removal, and the substitution of the crane of the dredge Susquehanna.

On the 4th of June, dredging of the Craighill channel was resumed and operations prosecuted vigorously, the tug Leslie, three dredges, and nine scows all being engaged. At the end of August the dredge Patapsco was removed to the bar of the Brewerton channel, just to the eastward of a line connecting North Point upper light and Seven-foot Knoll light. On the 17th of September the dredge Chesapeake was removed to a bar in the Brewerton channel, about one-quarter of a mile above the Patapsco, and on the 30th of the same month the Potomac was removed to the same bar.

This season's work, since June 4 to 30th of September ultimo, has been the removal of 63,635 cubic yards of material from the Craighill channel, and of 7,680 cubic yards from the Brewerton channel.

The Craighill channel has been thoroughly examined from its point of divergence from the Brewerton channel to its lower end, a distance of six miles, and for a width of two hundred feet, and it is believed there is not the slightest obstruction to vessels passing through it drawing less than twenty-one feet, there being this depth of water at mean low tide. The mode of searching for the lumps and little hillocks was novel, and it is believed to have been more effectual than by the ordinary use of the lead. It consisted of two poles loaded at bottom and provided with an iron shoe turned up at the ends so as to slide over the bottom of the channel. One of these poles was placed vertically on either side of the tug, a little in advance of midship, and held in position by guy ropes attached near the lower end of the poles and made fast to the steamer in front, and abaft the poles. The poles being marked in feet, were set to the proposed depth of the channel, (twenty-two feet,) and then the search was made by the tugs moving slowly ten times up and down the channel, at the proper distance each time from the edge of the channel. Of course by this arrangement the channel was quite thoroughly swept, and every lump or knoll would be indicated by the rising of the pole, and the exact depth shown on the pole to which the channel at those points should still be dredged. This test having been applied and showing no lumps or other obsturctions to a depth of twenty-one feet below mean water, it is believed, as before stated, that this depth may now be safely assumed as being available in every portion of the channel. Before, however, advertising the channel as open for vessels drawing less than twenty-one feet, I propose to examine still more thoroughly the bay just below the mouth of the channel to see that there are no oyster banks in that vicinity on which vessels might ground. It is believed that none exist, but still prudence dictates that this course should be observed.

Amount available July 1, 1868	$3,982 84
Amount of appropriation of July 25, 1868, appropriated to this work by Engineer Department July 30, 1868	17,000 00
Amount of appropriation of April 10, 1869, appropriated to this work by Engineer Department May 11, 1869	27,000 00
	47,982 84
Amount expended from July 1, 1868, to June 30, 1869	26,056 65
Amount available for expenditure during the year ending June 30, 1870	21,926 19

Amount required to widen the Brewerton channel from Fort McHenry to its intersection with the Craighill channel to a width of two hundred feet and a depth of twenty-two feet, as estimated for by Colonel Craighill in his report of January 15, 1867	$168,900 00
Appropriation required for the year ending June 30, 1871.	75,000 00

SUSQUEHANNA RIVER IMPROVEMENT.

Since the date of last annual report, the temporary structure or "deflector" was strengthened and stiffened, as suggested in that report, and the line was again occupied by the deflector early in November. It remained in action for about one week, when a violent wind storm, combined with a rise in the river, again disrupted it in several places.

During the short time in which it remained uninjured, however, a marked effect was produced on the "upper cut," (or dredged channel,) and the direction of the current leaving the deflector, was in the line required, and expected to produce a proper effect below.

As this structure was originally intended only to demonstrate the effect of an obstruction at the point selected, and the correctness of alignment, and as these objects were effected, (at least partially,) the material of the deflector was withdrawn to a sheltered position near the river bank, and has since remained in that condition under proper care and guardianship.

In view of the commercial importance of this harbor, I would suggest, in the event of any permanent works being contemplated for its improvement, that the object be effected by a line of submerged cribs of timber and stone placed along or near the line occupied by the deflector last season. These cribs would be located at intervals of about two or three times their breadth; their tops always submerged would avoid all danger of injury by ice or logs during freshets, and the retardation of the current produced by them would cause, I think, such a deposit of sediment as would in a few years produce a continuous bar along the line, which would effect the change of flow as desired.

It is estimated that the cost of these cribs would be about..	$40,000 00
From which deduct the available value of timber now on hand in deflector, say	8,000 00
The total cost for completed work would be	32,000 00

Amount available July 1, 1868	$13,500 95
Amount of appropriation of July 25, 1868, appropriated to this work by Engineer Department October 13, 1868...	5,000 00
Amount of appropriation of April 10, 1869, appropriated to this work by Engineer Department May 28, 1869	1,000 00
Amount derived from sales of property during the year...	534 40
	20,038 35
Amount expended from July 1, 1868, to June 30, 1869....	18,725 85
Amount available for expenditure during the year ending June 30, 1870	1,312 50

Very respectfully, your obedient servant,

J. H. SIMPSON,
Col. Engineers and Bvt. Brig. Gen. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

APPENDIX P.

UNITED STATES ENGINEER OFFICE,
Philadelphia, July 22, 1869.

SIR: In accordance with the requirements of circular of the 12th of June, 1869, from the office of the Chief of Engineers, Washington, D. C., I have the honor to transmit herewith annual reports for the following works of river and harbor improvement under my charge for the fiscal

year ending June 30, 1869, viz: Delaware breakwater, Delaware; improving harbor at Marcus Hook, Pennsylvania.

It will be seen the amount of revenue collected at the port of Wilmington, Delaware, is not given as required. On the 6th instant, letters of inquiry on that point were sent to the collectors of the ports of Philadelphia and Wilmington. On the 7th instant the desired information was received from the former official, by letter, dated the 6th instant.

No answer having been received from the collector of Wilmington, on the 19th instant a second letter of inquiry was sent him. Thus far he has not replied to either communication. Should he send the desired information, it will be forwarded for insertion in the two reports at the earliest moment practicable.

An abstract of proposals for stone and of contract for same, for Delaware breakwater, is transmitted also—in all three papers.

I have the honor to be, sir, very respectfully, your obedient servant,

C. SEAFORTH STEWART,
Lieut. Col. of Engineers.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

Report of progress made in the repair and construction of the Delaware breakwater during the year ending June 30, 1869.

From July 1, 1868, operations were carried on with a moderate force, the labor of receiving and placing in position the large stones of the superstructure being performed by days' work, the contractor for such labor having failed to comply with his contract. The stone was furnished by Messrs. Barker & Bodwell, from their quarries in Delaware, Maine, and Massachusetts, up to the 6th of October, when their contract was fulfilled.

Proposals for stone for the completion of the works having been invited and received, previous to that day, a contract, which was duly approved, was entered into on the 12th of September, 1868, with the lowest bidders, Messrs. A. O. & J. O. Deshong, jr., and John C. Leiper, to furnish all the stone that should be required, from the old breakwater quarries under their control near Chester, Pennsylvania. They were to begin shipping stone early in October, and sent during that month some 242 perches of small stones, but, as they stated they were unable so late in the season to procure proper vessels, it became necessary to suspend operations by the end of that month.

Work was resumed in the latter part of April, 1869, but no large stones were received under the new contract until the 10th of May, since which day, up to the 30th of June, 1869, steady and satisfactory progress has been made.

During the fiscal year, 9,040 tons of large stone for the superstructure were received and put in position on the breakwater and ice-breaker, completing 217 running feet at the east end of the former work, and 281 at the east end of the latter.

Some 5,263 perches of small stones were thrown overboard at the extremities of the breakwater proper, to protect the foot of the slopes, and, in part, fill holes excavated there by the action of the water, and 3,766 perches at the ends of the ice-breaker for the same object.

In all, about 2,430 running feet of the superstructure of the breakwater are now finished on the old base, leaving 120 feet to be raised to the full height to complete that work.

On the ice-breaker, about 646 running feet of the superstructure have been raised to the full height, leaving at the east end 240 feet still unfinished, and between the middle of the work and the west end (which is finished) about 475 feet, to be raised yet about 3 feet. To complete this work on the old base, therefore, about 715 running feet of the superstructure are to be constructed.

Two new surf boats have been built for the works, also a new crane and portable steam hoisting engine, which are just ready for use, on the ice-breaker; with these, if the contractors can be made to supply the stone rapidly enough, and political partisans do not succeed in getting control of the work, to the utter demoralization of the employés and the detriment of the funds of the United States, it is hoped both the breakwater and ice-breaker may be completed this season, or, at the latest, during the fiscal year ending June 30, 1870, with the funds still available.

EXPENDITURES TO JUNE 30, 1869.

Paid for stone, to Barker & Bodwell		$26,747 55
Paid for stone, to A. O. & J. O. Deshong, jr., and John C. Leiper		34,825 54
Total paid for stone during the year		61,573 09
Total paid for machinery, cranes, engines, blocks, rope, chains, boats, buoys, &c		5,277 81
Total paid for services of mechanics and laborers		7,273 24
Contingent expenses, superintendent, inspector's office, &c.		6,673 43
Total expended during the year		80,797 57
Expended years ending June 30, 1867, and 1868		62,943 35
Total expended from appropriations to June 30, 1869		143,740 92
Cash received during the year		$75,856 65
In the treasury July 1, 1869		78,603 70
Due from the United States July 1, 1869	$4,940 92	
Due contractors for stone received, not paid for	10,761 08	
		15,702 00
Available for the year ending June 30, 1870		62,901 70
Amount that can be profitably expended during the year ending June 30, 1870		$62,901 70

No appropriation is asked for.

The breakwater is located in the collection district of Delaware. The nearest port of entry is Wilmington, Delaware. There is a light-house upon the breakwater and others on Cape Henlopen.

Fort Delaware is the nearest fort.

The amount of revenue collected at Wilmington during the fiscal year is reported as $———.

The following table, taken from such imperfect records as have been kept from time to time, gives the number of vessels of each class avail-

ing themselves of the breakwater during the different periods therein specified:

Y'rs.	Ships.	Barks.	Brigs.	Schooners.	Sloops.	Pilot boats.	Steamers.	Total.	Remarks.
1833	22	....	178	372	167	127	....	866	From Sept. 1, inclusive.
1834	48	....	315	667	303	411	....	1,744	July 1 to Oct. 17, not
1835	133	....	569	1,719	461	644	....	3,526	recorded.
1836	301	....	1,027	2,719	620	767	....	5,434	
1837	227	....	478	2,777	629	732	....	4,843	
1838	165	....	732	3,191	765	685	....	5,533	
1839	165	....	504	3,561	734	697	....	5,661	
1840	172	....	279	1,909	308	371	....	3,039	To June 3, inclusive.
1841	111	....	902	3,916	590	483	....	6,002	From May 1.
1842	107	....	1,060	5,335	802	794	....	8,098	
1843	103	....	841	4,981	1,167	792	....	7,884	
1844	231	....	969	5,797	854	744	....	8,595	
1845	265	....	1,042	5,446	597	776	....	8,126	
1846	258	....	1,625	6,711	614	781	....	9,989	
1847	342	....	1,937	7,742	358	874	....	11,253	
1848	340	....	1,457	6,037	374	918	....	9,126	
1849	329	....	804	3,261	168	553	....	5,115	
1854	35	247	1,085	5,098	90	....	114	6,669	From Apr. 1, inclusive.
1855	65	240	855	6,808	128	....	243	8,339	
1856	116	425	1,062	6,125	256	....	286	8,270	
1857	79	331	981	5,348	213	....	220	7,177	
1858	6	34	78	1,030	174	....	38	1,360	To Mar. 31, inclusive.
1862	55	239	879	8,087	253	....	246	9,759	From Feb. 1, inclusive.
1863	231	345	1,040	7,092	251	....	347	9,306	
1864	231	308	1,155	7,781	189	....	299	9,963	
1865	274	378	1,179	6,056	209	....	372	8,468	
1866	28	227	694	6,747	299	....	316	8,311	
1867	113	290	825	8,000	307	....	279	9,814	
1868	62	446	908	8,373	205	....	384	10,378	
1869	19	84	241	3,797	301	....	172	4,614	To June 30, inclusive.
Total	4,633	3,594	25,701	146,483	12,391	11,149	3,316	207,267	

If correct, 207,267 days' shelter have been afforded vessels of all classes, by these works; upon an average, therefore, for each recorded day of these thirty years, twenty-one vessels have used this harbor.

Abstracts of proposals and of contract for stone are transmitted herewith.

It is thought injuries to the works, from storms and ice, may possibly, in the course of fifteen years, require for repairs an appropriation of $22,500.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieut. Col. of Engineers.

PHILADELPHIA, PA., *July* 20, 1869.

Abstract of proposals for stone for Delaware breakwater.

No.	Name of bidders.	First class.	Second class.	
		Per ton, (2,240 lbs.)	Per ton, (2,240 lbs.)	Per perch, (25 cub. ft.)
1	James W. Andrews	$4 25	$4 25	$8 75
2	James Armstrong and Peter Quinn	3 87	3 74	6 70
3	Henry McIlvain	4 19	3 19	3 85
4	Richmond Granite Company	4 25	3 75	6 25
5	Conshohocken Stone Quarry Company	4 64	2 99	4 24
6	A. O. and J. O. Deshong, jr. and John C. Leiper	3 89	2 89	3 10
7	Jos. Wescott & Son	4 00	3 75	5 62
8	Henry Barker and Jos. R. Bodwell	3 99	3 49	5 23

C. SEAFORTH STEWART,
Lieut. Col. of Engineers.

PHILADELPHIA, PA.

Abstract of contract for stone for Delaware breakwater.

Contractors.	First class.	Second class.	
	Per ton.	*Per ton.*	*Per perch.*
A. O. and J. O. Deshong, jr. and John C. Leiper	$3 89	$2 89	$3 10

C. SEAFORTH STEWART,
Lieut. Col. of Engineers.

PHILADELPHIA, PA.

Report of progress made in improving harbor at Marcus Hook, Pennsylvania, during the year ending June 30, 1869.

Since July 1, 1868, operations on the crib-work for the new piers have been progressing very slowly. One crib has been constructed in part, and put in position, but has not yet been filled and sunk to hard bottom; a second has been put in position, and is ready for its platform; the platforms have been put in the remaining two, which are now ready to receive the superstructure.

Owing to the inattention, mismanagement, and bad faith of the contractor for crib-work, Abraham P. Eyre, full two years have been worried away in completing two out of four cribs. According to his promises, of which he has always been remarkably profuse, he was, after the extension of time granted last year, to have finished all the crib-work that season. It is now possible he may complete the two unfinished during the present year. The other contractors have been much annoyed by Mr. Eyre's tardy proceedings and have made but little headway, consequently, in their preparations. As the wages of stonecutters have been raised considerably since they contracted for the stone work, while Mr. Eyre has been delaying them, they may yet fail to fulfill their contracts. It is expected, however, that the construction of the superstructure of one, or both, of the finished cribs will be begun during July, 1869. While these are under construction, the rest of the crib-work may be finished, and it is hoped the stone work of the piers may be during the season.

During the year 4,944 feet face of timber have been expended on the crib-work, and 4,605 pounds of bolts; 4,791 pounds of bolts and dowels for cribs and for superstructure are on hand. In filling and sinking the cribs to hard bottom, 3,183½ perches of rubble stone have been received and expended.

EXPENDITURES.

Iron bolts and dowels	$1,066 13
Rubble filling stone	3,494 40
Labor on crib-work	1,298 85
Contingent expenses inspector's office, &c	3,180 35
Total expended during year ending June 30, 1869	9,039 73
In hands of agent June 30, 1869	9,725 79
Total in his hands during the year	18,765 52

Of which $18,000 were drawn from the Treasury, and $765 52 balance from preceding year.

In Treasury June 30, 1869		$52,950 00
In hands of agent June 30, 1869	$9,725 79	
Due retained from contractors June 30, 1869	3,654 44	
		6,071 35
Available for year ending June 30, 1870		59,021 35
Can be profitably expended during year ending June 30, 1870		$59,021 35

No appropriation is asked for.

Marcus Hook is situated in the collection district of Philadelphia. The nearest port of entry, light house and fort, are, respectively, Wilmington, Delaware, Christiana light, and Fort Mifflin.

The amount of revenue received at Wilmington during the past fiscal year is reported as $———.

That received during the same year at Philadelphia is given as $8,470,732 31 in coin.

At the expiration of ten years, the wood-work of inner piers, wharves and landings may require repairing to the amount of $5,000.

How far this harbor will benefit commerce and navigation is not known.

Respectfully submitted.

C. SEAFORTH STEWART,
Lieut. Col. of Engineers.

PHILADELPHIA, PA., *July* 21, 1869.

APPENDIX Q.

UNITED STATES ENGINEER OFFICE,
Army Buildings, New York, August 31, 1869.

GENERAL: I have respectfully to submit herewith a report upon the progress and condition of the works of improvement of the Hudson River, between Troy and New Baltimore, during the fiscal year ending June 30, 1869.

PROGRESS OF THE WORKS.

The opening of the year found us at work driving piles of the new dikes at Cedar Hill and at Cow Island, which were commenced in the month of May preceding.

The Cedar Hill and Cow Island dikes have been finished; their lengths are 5,739 and 3,960 feet, costing $49,976 77 and $30,475 13, at the rate respectively of $8 71 and $7 69⅘ per lineal foot. The cost in each case includes expense of re-filling with stone where the usual settlement after the first completion had taken place. The Cedar Hill dike is not continuous, having in its line an open space of 1,000 feet. This has been very useful in passing through it large quantities of sand, &c., which have been deposited in the side basin, and have thus relieved the main channel.

The effect of these two dikes has been, by defining the channel and by properly directing the flow of the water, to increase the depth over Cedar Hill Bar from 7.5, as existed before the commencement of the dike, to 9.2 feet. Thus far, during the present season of navigation there has been no trouble at this bar, and it is supposed that little or no dredging

will be needed. Cedar Hill Bar was formerly a bad and troublesome bar.

These dikes were finished during the last working season.

A contract was made in the spring of 1868 for the removal of the old State dam, extending into the channel and situated just below Cedar Hill; the contractor failing to perform the work, it was undertaken in the months of October and November, 1868, by the United States. Four thousand one hundred and forty cubic yards of stone and sand, as well as large pieces of timber, were removed, at a cost of $1,186 45.

The dam has been so broken up and the stone and debris remaining are so scattered as well as diminished in amount, that it remains doubtful whether a further removal is necessary.

Tobias S. Van Hovenbergh's contract for removing the face of Mull's Island, at 21 cents per cubic yard, was completed and the last payment made December 7, 1868. One hundred and fifty-eight thousand three hundred and seventy-six cubic yards were removed during the past working season.

The Coeyman's dike has been prolonged southward during the last working season, along the face of Mull's Island, by the construction known as the half dike, for the space of 1,640 feet, at a cost of $5 51½ per lineal foot, amounting to $9,045 17. The extension of this half dike, to meet the upper end of the New Baltimore dike, will be completed during the present season.

The effect of enlarging the width between Barren and Mull's Islands has already been sensibly felt in the increase of the flow of water, as has been demonstrated by a considerable movement down stream of the large middle ground opposite the village of Coeyman's. Large deposits from this shoal have already formed at the north end of Barren Island, and it is confidently believed that a large amount has lodged in the space between Barren Island and the west bank of the river. It is expected that considerable useful effect will likewise result from the projected dredging of the channels at the Coeyman's Crossover, between Barren and Mull's Islands, and in front of the New Baltimore dike; and that further reduction of the size and increased deposit of the central middle ground in the side basins, as well as a straightening of the channel, will result from this operation, over and above the local increase of depth in the channel. The widening of the channel between Barren and Mull's Islands, and the increased flow of water resulting, has likewise increased the depth of water in the channel along the upper part of the New Baltimore dike. At the lower end of this dike, the current, striking the face of Houghtailing Island too abruptly, has been deflected and an eddy created, which has formed a deposit with the materials washed from the island shore. The cutting away of the face of Houghtailing Island, as recommended in previous annual reports, would, undoubtedly, by removing the cause, arrest this deposit.

It is necessary here to notice the New Baltimore dike, 5,900 feet long, a strong and substantial structure built by the commissioners of the State of New York. This dike was intended to be straight, but unfortunately, by error of construction, was made at a certain point convex or rather salient to the channel, thereby tending to deflect the currents from the dike, which was a defect, because the channel was designed to lie along the dike. But it must be remarked that even if the dike had been constructed perfectly straight, such form would have been defective for a structure of great length, as a straight line has no power to retain a volume of water flowing along its length, or to prevent the dissipation thereof.

A concave dike would have accomplished the purpose much better. It is due to the State commissioners, whose works have sensibly improved the river, to state that they worked without a map, there being no good one in existence at the time, and that a plan of improvement, without the suggestions furnished by a correct map, must necessarily fail in details however sound the general principles might be.

It is proper to say that I anticipate trouble resulting from the plan of this dike; but I prefer, before indicating which of the several modifications that suggest themselves should be adopted, to wait until the channels along the dike at Mull's Island and Coeyman's Crossover shall have been dredged, and the effect of a freer flow of water observed.

It may be that, in spite of the defective plan of the dike, a free flow of water may compensate for its defects so far, at least, as to secure a reasonably good channel.

In August, 1868, operations were commenced by prolonging Cuyler's dike near Dnow's Point, in a concave direction, to deflect properly the current and throw it into the proper channel leading toward the over-slough dike, and at the same time prevent the washing of the stone and consequent filling of the channel; this dike, 1,664 feet long, was completed before the close of navigation, at a cost of \$12,229 39, or \$7 34½ per foot; the sinking of stone during the winter will render it necessary to throw in an additional quantity, which will raise the cost to about \$7 50 per foot.

In January, 1869, the sudden break up of the ice in the Mohawk River brought down large quantities which dammed against the railroad bridge at Albany, creating a head of water above, which was discharged through the cut connecting the basin with the river above the bridge. The immense velocity of the water passing through the basin undermined at a great depth the foundations of warehouses, causing great damage to private property.

A shoal at the same time was formed at the draw of the bridge, which was afterward removed by the Bridge Company. Fish-house Shoal, above, was so increased as to prove a serious impediment to navigation. The large shoal near the east bank, which is situated under and above the bridge, ought to be removed in part, in order to straighten the great deflection now existing in the channel from Bath across to the wharves at Albany. But it will be perceived that so long as the river remains encumbered by the great number of piers which enter into the construction of the bridge, the permanent benefit to be derived from dredging would remain a matter of doubt.

We perceive clearly, therefore, the immediate effects of the bridge in causing ice-dams, shoals, and obstructions to the free flow of water, as well as damage to property, effects which are either periodic or continuous.

The existence of the bridge with its present multiplication of piers is a formidable obstacle to the permanent improvement of the reaches of the river, and may defeat or impair materially the best devised plan. I think, however, the shoal spoken of should be dredged, and the curved dikes at Bath and Patroon's Upper Island constructed. These would undoubtedly prove of benefit.

The close of navigation, December 5, 1868, necessitated the suspension of operations. During the winter plans were made for the next season, and the necessary contracts entered into.

A dike at Boah Brook, to deflect the water into the eastern channel at Barren Island, was commenced in the month of May, 1869, and completed June 30.

The dike is 1,814 feet long, a portion being built in 15 feet of water, and cost $18,222 04, or at the rate of $10 10 per lineal foot.

A dike was likewise commenced at Parda Hook, to deflect properly the current over Cedar Hill Bar, as likewise to protect the shores. As the line of this dike would cross the existing channel, it was necessary, in order to provide for the immediate requirements of navigation, to dredge a new channel. A contract for this object was made with Emory R. Seward for the gross sum of $15,900, the cubic contents calculated in the bank being 59,279 cubic yards.

The shore of Bear Island, above the starting point of the dike, needed protection, and work was likewise commenced there.

The progress made at this locality up to June 30, 1869, was at Parda Hook dike; 59,078 feet of piles driven for the Bear Island protection; 3,870 feet of piles driven, and considerable progress made in dredging the channel. An extension of the Castleton dike northward was likewise commenced, and up to June 30, 1869, 19,474 feet of piles were driven.

The surveyor, R. H. Talcott, civil engineer, has been busily employed during the past year in completing the general survey and map, and in making a tracing of the same; in making resurveys of various bars and localities upon the river for comparison, or for the contractors' use in laying out the lines of dikes, and in tidal observations; and his services have been eminently faithful and efficient.

Brevet Colonel John M. Wilson, corps of engineers, who is stationed at Albany, in personal supervision of the operations, is entitled to great credit for the energy and efficiency with which in the midst of many obstacles he has pushed the work.

The results of the operations thus far completed have been gratifying, and comparatively little trouble has been experienced at the bars below Albany, though we have as yet disbursed no money to dredge the bars and shoal places.

Information supplied in conformity with requirements of circular from office of the Chief of Engineers, dated June 12, 1869:

1. Amount that will be required for the entire and permanent completion of the work is $273,560 31, and in addition there will probably be required for dredging the channel between Albany and Troy an annual outlay of about $20,000.

2. The amount that could be profitably expended during the next fiscal year would be $163,000.

3. Statement of expenditures from July 1, 1868, to July 1, 1869, and of amounts available July 1, 1869, from the various appropriations for improvement of Hudson River, New York.

Appropriation of 1864 *for repairs of harbors on the Atlantic coast.*

Amount available July 1, 1868, as per last report	$681 99
Expended during the year	481 08
Balance	200 91
Due for internal revenue tax, as far as known	138 48
Amount available July 1, 1869	62 43

Appropriations of 1866 *and* 1867 *for improvement of Hudson River, New York.*

Amount available July 1, 1868, as per last report........	$179,395 96
Expended during the year..................................	161,328 59
Balance..	18,067 37
From which amount there has been reserved in the treasury, at Washington, to settle account between this appropriation and the Internal Revenue Bureau, as per note on letter of May 25, 1869, from the office of the Chief of Engineers..	288 00
Amount available July 1, 1869..............................	17,779 37

Appropriation for repair, preservation, extension, and completion of river and harbor works, approved July 25, 1868.

Amount allotted for improvement of Hudson River, New York, as per letter of July 31, 1868, from Headquarters Corps of Engineers..	$85,000 00

Appropriation for improvement of rivers and harbors, approved April 10, 1869.

Amount allotted for improvement of Hudson River, New York, as per letter of May 11, 1869, from office of Chief of Engineers..	$90,000 00
Total amount available July 1, 1869.........................	192,841 80

Appropriations for examinations and surveys on the Atlantic coast.

Amount received during the year........................		$2,050 00
Due from the United States July 1, 1868, as per last report.............................	$239 16	
Expended during the year..............................	1,766 22	
		2,005 38
Amount on hand July 1, 1869.............................		44 62

Amount available July 1, 1869, unknown.

It is likewise required to give an account of the steps taken for the prosecution of the work during the present working season, and the probable progress that will be made therein.

Roah Hook dike undertaken, and will be completed during present working season.

Protection of Bear Island undertaken, and will be completed during present working season.

Extension northward of Castleton dike undertaken, and will be completed during present working season.

Dike to connect Castleton and Schodack dikes, to protect shores from continuance of serious abrasions to the injury of the channel, has been undertaken; how much will be done during the present season is a matter of doubt, as it is requisite to wait until projecting points are removed before the line of dike can be completed. Dredging in channels at Coeyman's Crossover, between Barren and Mull's Islands and along New Bal-

timore dike, has been undertaken, and is under agreement to be finished during the present working season.

In presenting the subjoined estimate it is essential to remark that, to finish works already commenced and meet outstanding liabilities contracted thereon, as likewise to dredge channels along New Baltimore dike, between Barren and Mull's Islands, at Coeyman's Crossover and at Cedar Hill Bar, to construct half dike at Mull's Island, dike at Coeyman's, connecting dike between Castleton and Schodack dikes, protection of Shad Island, to dredge shoal under and above railroad bridge at Albany, to construct dike at Bath, and extension of old United States dike at Upper Patroon's Island, and to remove several old State dams—

The sum required would be	$256, 411 20
On hand July 1, 1869	192, 841 80
To be appropriated	63, 570 40

The cost of several works contained in the estimate are not herein included, and it is doubtful whether these should be undertaken at present, for I conceive it to be good policy to allow the works already commenced, as well as those specially enumerated by name above, when finished, some time to produce their full effects, before the full estimate for the river should be devoted to its improvement. As it would be necessary to have on hand a surplus to meet contingencies possible in the improvement of a river, even now undergoing important changes in its regimen, due to works recently finished, I consider it essential to increase the amount, $63,570 40, estimated to be necessary to finish and construct certain enumerated works, to $100,000.

No estimate has been made for works above the bridge at Albany, except the removal of the shoal at the bridge, the construction of the Bath dike, and the extension dike at Upper Patroon's Island, recommended to be immediately undertaken.

To dredge and keep open the channel between Albany and Troy, I suppose, might amount to an average annual expenditure of $20,000, and this must be considered as additional to the subjoined estimate.

The reasons for doubting the practicability of a permanent improvement for the whole river between Albany and Troy have already been fully given in this and the preceding report.

Estimate to complete the improvement of the Hudson River according to plan submitted.

Cutting off face of Houghtailing Island:

Damages to private property, 24 acres, at $100	$2, 400 00
Excavation, 391,000 cubic yards, at 20 cents	78, 200 00
Half dikes, 1,320 linear feet, at $6	7, 920 00
Shore protection, 920 linear feet, at $3	2, 760 00
Dredging channel at New Baltimore dike, 130,000 cubic yards, at 23 cents	29, 900 00
Dredging channel between Barren and Mull's Islands, 43,000 cubic yards, at 23 cents	9, 890 00
Completing half dike at Mull's Island, 1,600 linear feet, at $5 50	8, 800 00
Dike at Coeyman's, 2,000 feet, at $6	12, 000 00
Dredging channel at Coeyman's Crossover, 70,000 cubic yards, at 23 cents	16, 100 00

Payment made, after July 1, upon completed dike at Roah Hook	$9,517 83
Connecting Castleton and Schodack dikes for protection of shores, 954 linear feet, at $7 50	7,155 00
Shore protection at Shad Island	4,800 00
Finishing extension northwards of Castleton dike	13,011 20
Closing gap in Cedar Hill dike, 1,000 linear feet, at $8 71	8,710 00
Dredging Cedar Hill bar, say	8,000 00
Finishing dike at Parda Hook	25,328 71
Dredging new channel at Parda Hook, by contract	15,900 00
To finish shore protection at Bear Island	1,146 37
8,000 feet of dike parallel to Overslaugh dike	80,000 00
Removing Overslaugh rock, 468 cubic yards, at $13	6,084 00
Removing 775 linear feet of old State dam, along Overslaugh dike	2,712 00
Dredging channel along Cuyler's dike, 100,000 cubic yards, at 23 cents	23,000 00
Dredging shoal under railroad bridge, 60,000 cubic yards, at 23 cents	13,800 00
Dike above Bath, 5,693 linear feet	55,297 00
Removing old State dam	1,500 00
Extension of old United States dike at Upper Patroon's Island, 1,820 linear feet	15,470 00
Expenses of survey	6,000 00
	466,402 11
Amount available July 1, 1869	192,841 80
Amount necessary to be appropriated	273,560 31

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. of Engineers and Bvt. Maj. Gen. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., May 31, 1869.

GENERAL: Your letter of the 29th instant, reporting that the opening of Mull's Island channel has already had a great effect upon the Coeyman's bar, and transmitting tracing, &c., is received.

Your action in stopping the Le Roy Hook dike is approved, and you are authorized to construct a curved dike at the lower end of Coeyman's channel, in order to deepen the water in front of Coeyman's, and to keep open a small channel between it and Barren Island.

By command of Brig. Gen. Humphreys.

Very respectfully, your obedient servant,

JNO. G. PARKE,
Major of Engineers, Bvt. Maj. Gen. U. S. A.

Bvt. Maj. Gen. JOHN NEWTON, U. S. A.,
Lieutenant Colonel of Engineers,
27 *West Houston Street, New York City.*

Q 1.

UNITED STATES ENGINEER OFFICE,
CORNER GREENE AND HOUSTON STREETS,
New York, September 22, 1869.

GENERAL: I have the honor to transmit the following report of the operations at the Hell Gate improvement for the fiscal year ending June 30, 1869:

On July 31, 1868, I was notified by letter from Headquarters Corps of Engineers that an allotment of $85,000 had been made from the appropriation for "repair, preservation, extension, and completion of certain public works on rivers and harbors" for removing obstruction in the East River, including Hell Gate.

New surveys of Frying Pan and Pot Rock were immediately commenced for the purpose of ascertaining the amount of rock to be removed so as to give a depth of twenty-five feet mean low water.

Advertisements calling for proposals to remove Frying Pan and Pot Rock were inserted in the New York, Boston, Philadelphia, and Chicago papers, and on September 21, 1868, the proposals were opened, (abstract of bids herewith,) and by the terms of the law the contract was awarded to Mr. Sidney F. Shelbourne, his bid being the lowest.

Mr. Shelbourne had a machine under construction which he intended to put to work upon the rocks, but, after testing its qualities, it was decided to make some alterations in the motive power, substituting steam for water; with this machine a diamond drill, two inches in diameter, was operated. After many delays and some modifications the machine was put to work on Frying Pan Rock, on or about the 13th January, 1869. Several holes were drilled into the rock for the purpose of mooring the boat assisting in the work, but the machine was finally laid aside by the contractor in order to construct another, capable of making holes of greater diameter in the rock, with the view of expediting the work.

The contractor then commenced the construction of a larger and more powerful machine on a different principle, discarding the rotating diamond drill, and using instead the drop drill worked by steam.

The time granted by the contract having expired without having made any progress toward removing the rock, it was, by permission of the Secretary of War, extended to August 15, 1869. Up to the expiration of the fiscal year ending June 30, 1869, the new machine had not been put to work. On May 11, 1869, I was notified that an allotment of $180,000 for the improvement of the East River had been made from the appropriation for "improvement of rivers and harbors."

On June 9 I submitted a project for the removal of Hallett's Point by sinking shafts, between high and low-water marks, to a sufficient depth from the bottom of these shafts to run galleries under the rock to be removed.

At the same time, I also proposed to undertake the removal of the channel rocks by means of a machine of my own invention, as described in the same letter.

On June 17 I made an agreement with Messrs. Maillefert, Gibbs, Bliss & Gumbs, for the removal of the rocks known as Pot Rock, Way's Reef, and Shell Drake, at the rate of forty-four dollars and twenty-eight cents per cubic yard, with the understanding that they should commence operations in two weeks after the date of the contract; that delay being necessary in order to obtain a sufficient number of

soundings to make an accurate delineation of Way's Reef and Shell Drake, which had not before been surveyed.

There were, then, the contracts of Mr. Shelbourne and Maillefert & Co. for the removal of Frying Pan, Pot Rock, Way's Reef, and Shell Drake, and the initiatory steps of the government to undertake the work at Hallett's Point and in the channel, together sufficient to absorb all the funds appropriated by Congress for this work.

Surveys have been made of Pot Rock, Frying Pan, and Way's Reef, in Hell Gate, and a great part of Diamond Reef, in the East River, has been surveyed.

FIELD WORK.

The hydrographic statistics are as follows:

	Pot Rock.	Frying Pan.	Way's Reef.	Diamond Reef.	Total.
Angles measured	2,151	4,434	2,256	990	9,831
Number of soundings	3,871	8,304	4,332	1,980	18,487

TOPOGRAPHY.

The topography of northeast shore of Governor's Island was finished, and the shore survey at Hell Gate commenced.

TIDES AND CURRENTS.

Regular tidal observations, by means of box tide-gauges, have been made.

Four tidal stations were occupied at Hell Gate on account of the great irregularities caused by the form and by the obstructions in this passage above and below water.

The velocities and directions of the tidal currents were observed both at the Gate and off Governor's Island.

SIGNALS.

Ranges on shore were erected for the contracting parties whenever needed.

OFFICE WORK.

The soundings taken on Pot Rock, Frying Pan, Way's Reef, and Diamond Reef, have been plotted in a scale of $\frac{1}{300}$.

The areas and cubic contents of the rocks to be removed were calculated.

The first and second reductions of the tidal observations were made.

FINANCIAL STATEMENT.

Amount of allotment from appropriation of July 25, 1868		$85,000 00
Amount expended		6,135 62
Amount available July 1, 1869		78,864 38
Amount in treasury	$77,700 00	
Amount in hands of agents	1,164 38	
		78,864 38

No expenditures have been made from the appropriation of April 10, 1869.

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. Engineers and Bvt. Maj. Gen. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

Improvement of Hell Gate, New York.

UNITED STATES ENGINEER OFFICE,
No. 27 WEST HOUSTON STREET,
New York, August 10, 1868.

Sealed proposals for the removal of the rocks known as Frying Pan and Pot Rock, situated in Hell Gate, East River, will be received at this office until noon of September 21, 1868.

These rocks must be removed to a depth of twenty-five feet mean low water, and the debris deposited where the engineer may direct. The estimated cubic contents of Frying Pan to be removed are 1,364.8 cubic yards, over an area of 1,222.2 square yards. The estimated cubic contents of Pot Rock to be removed are 576.1 cubic yards, over an area of 1,302.2 square yards.

Bids must state separately the sums asked for the removal of Frying Pan and Pot Rock, and payments will be made when one entire rock shall be removed, amounting to the entire sum agreed upon for that rock, less a reservation of ten per cent., to be paid when the entire work is done.

As new and more detailed surveys will be made of these rocks, the accepted bids may be increased or diminished in amount, according as the quantity of work shown by the new surveys shall be greater or less than that deduced from existing surveys, and the amount of work in the removal of these rocks will be held to be proportional to the surface and cubic contents.

All calculations of area and cubic contents will be taken from the official maps of this office, and will be accepted as correct by both parties.

Each bid must be accompanied by a guarantee of two responsible persons that the bidder will execute a contract.

Forms of proposals and of guarantees can be obtained at this office.

The United States reserves to itself the right of contracting for the removal of one only of these rocks, should this be deemed advisable.

Proposals should be indorsed upon the envelope, "Proposals for removing rocks at Hell Gate."

Drawings of these rocks can be inspected at this office.

Proposals should state likewise the time asked for the removal of these rocks.

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen. U. S. A.

Improvement of Hell Gate.

UNITED STATES ENGINEER OFFICE,
No. 27 WEST HOUSTON STREET,
New York, August 20, 1868.

For the information of those intending to bid for the removal of rocks in Hell Gate, it is necessary to state that the contract will not necessarily be assigned to the lowest or to any bidder.

The time which the bidder proposes to consume in performing the work, as well as the character of his proposed mode of operations, as to practicability, will likewise be considered in assigning the contract.

JOHN NEWTON,
Lieut. Col. of Engineers and Bvt. Maj. Gen. U. S. A.

Abstract of proposals received in answer to advertisements of August 10 *and* 20, 1868, *for the removal of the rocks known as Frying Pan and Pot Rock, situated in Hell Gate, East River, New York, opened at* 12 *o'clock, noon, on September* 21, 1868.

Bidders.	Amount asked for removal of—		Time asked for removal of—		Time asked to remove both rocks.
	Frying Pan.	Pot Rock.	Frying Pan.	Pot Rock.	
George H. Bradbury	$129, 780 00	$60, 480 00	Dec. 31, 1869	April 15, 1869	
Sidney F. Shelbourne	24, 307 09	13, 498 02			Dec. 10, 1869
E. R. Lowe	60, 000 00				
Wm. H. Cammeyer, Samuel Lewis, Ariel Patterson	325, 000 00	175, 000 00			Nov. 1, 1869
John J. Flanagan	65, 000 00	20, 000 00	Aug. 1, 1869	Nov. 1, 1869	
George E. Lincoln	45, 000 00	35, 000 00			Sept. 30, 1869
B. Maillefert*	42 50 per cub. yd.	44 28 per cub. yd.	May 1, 1869	May 1, 1869	
A. D. Bishop	65 00 per sq. yd.				
David Babcock	153, 659 00	57, 500 00			Sept. 15, 1869
Murphy, Pontez & Baldwin †	1 60 per. cub. ft.	2 00 per. cub. ft.			July 1, 1869

* Frying Pan, $58, 004; Pot Rock, $25,509 70. † Frying Pan, $58,959 36; Pot Rock, $31,109 40.

I certify that the above abstract is correct,

JOHN NEWTON,
Lieut. Col. of Engineers and Bvt. Maj. Gen. U. S. A.

NEW YORK, *June* 9, 1869.

GENERAL: In accordance with the requirements of the last paragraph of your letter of instructions of May 11, in relation to action under the allotment of $180,000 for the improvement of the channel at Hell Gate, I have to propose the following plan of operations:

In addition to the contract of Mr. Shelbourne, to employ several other parties upon the removal of rocks in the channel at Hell Gate, and in East River.

To commence, on the part of the government, upon the rock at Hallett's Point, by sinking shafts between high and low-water marks to a suitable depth; from the bottom of these shafts to lead galleries under the rock to be removed, the galleries eventually to be opened into one large space, and the rock overhead supported by wooden shores; the

opening below being calculated to receive all the rock from above, and, at the same time, give the requisite draught of water; the galleries to be kept separated by solid walls of rock, until the full length of each has been excavated, so that a flooding of one gallery may not lead to the same disaster in all. Whether or no this system may hereafter be abandoned for another more expeditious and cheaper would be a matter for future consideration. To this time, at least, no other process has indicated so effectual a promise of a completely successful result. Should this method be afterwards laid aside for one better, the work done is, at least, always available for the placing of mines to overthrow the rock. Should the water come in in such quantities as to arrest the further progress of the galleries, at least all the lengths that have been completed will be available for blasting charges.

This method is recommended for the removal of that portion of Hallett's Point already acquiesced in in the report of the Chief of Engineers, and refers particularly to the projecting reef under high water. Should it be deemed advisable, hereafter, to take off a large slice above high-water mark, the work for this could go on simultaneously with the first.

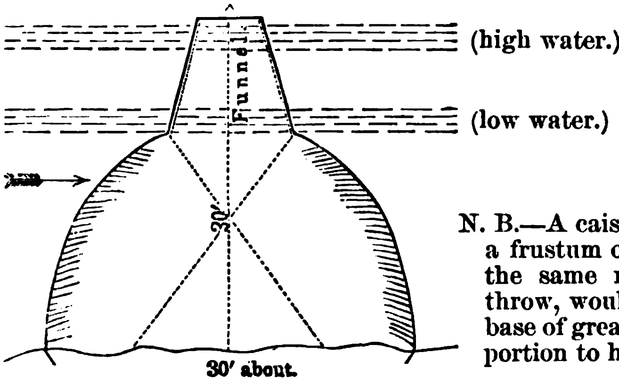
As soon as the survey of Hallett's Point and Negro Point shall be finished, I shall be prepared to submit a definite project for the amount necessary to be taken off from the shore line at the former place, besides the removal of the reef under high water.

The surveys we already have are sufficient to commence the work.

Besides the above, it will be necessary for me to hire a portion of ground, or rock rather, at Hallett's Point, upon which to erect a blacksmith's shop and store-room for tools, &c.

In addition to this project for the removal of Hallett's Point, which likewise would apply to the removal of the Gridiron, (should that be finally thought necessary to be done,) I propose, in view of ultimate want of success on the part of the contractor and others in the removal of the channel rocks—a contingency which at least is possible—to construct a boat and machine for the government; the boat to be about 120 feet long and 50 feet beam, in the shape of a scow, with a deck two to two and one-half feet thick, projecting four feet beyond the hull, and furnished on the edge with iron plating, say two inches thick. This construction to stand the shock of collisions, and a well of about 30 feet wide by 40 feet long in the boat, through which to raise and lower the caisson from and to the bottom, constitute the features of the boat.

The caisson to be constructed thus:



N. B.—A caisson of the shape of a frustum of a cone, to oppose the same resistance to overthrow, would require to have a base of greater diameter in proportion to height.

The above construction being designed so that the ultimate pressure of the water running with great velocity, which is normal to the surface,

and falling within the area of the base, will not actually tend to overthrow the machine.

The drilling machines are separate from the caisson, and may be changed at will.

Of course I do not pretend to say there is not much yet to be learned, but this will never be done unless I set to work.

Very respectfully, general, your obedient servant,

JOHN NEWTON,
Brevet Major General.

Maj. Gen. A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

Q 2.

NEW YORK, *February* 16, 1869.

GENERAL: I have the honor, in compliance with instructions from Headquarters Corps of Engineers of the 4th instant, to present the following plan and estimates for the improvement of the harbor of Rondout:

1. To direct the down current of Rondout Creek, and to concentrate its action for the permanent improvement of the bar; a north dike, concave to the channel and 660 yards in length, is designed.

2. To guide the down current of the Hudson near the western bank, into a direction nearly coincident with the current issuing from the creek, in order to insure the co-operation of both in the transport of silt away from the mouth of the harbor, the branch dike, springing from the extreme end of the north dike, and running in a northerly direction, is recommended. This dike should be concave toward the channel of the river, and may be about 300 yards in length.

The two dikes first described are considered of first importance, and would, undoubtedly, of themselves cause an amelioration of navigation.

3. But to develop the full capacity of improvement of this locality, the south dike, 1,200 yards in length, should also be constructed, and without such dike it would likewise be a matter of doubt whether a navigable channel of sufficient width could be maintained.

4. Dredging a channel 100 feet wide, 2,100 feet long, and of 14 feet depth at mean low water, might likewise be necessary.

From information collected from those who should be acquainted with the facts of the case, it is inferred that the work of dredging could be easily executed.

The directions and lengths of the dikes, as recommended, may be subject to modification from information to be hereafter derived from examinations and surveys.

Owing to the season of the year at which the call was made upon me to prepare plans and estimates, I have been obliged to content myself with the information compiled in existing coast survey charts, and that derived from individuals acquainted with the locality.

The mode of construction of the dikes is supposed to be the same as of those already constructed under my charge upon the Upper Hudson; the information collected as to the nature of the bottom being to the effect that piles can be driven with facility.

The prices of material and labor are assumed not to be essentially different from those paid upon the works of improvement of the Upper Hudson.

ESTIMATE.

North dike, 660 yards long	$35,410 47
Branch dike, 300 yards long	13,968 83
South dike, 1,200 yards long	52,636 26
Amount	102,015 56
Dredging channel, 2,100 feet long, 100 feet wide, to depth of 14 feet at mean low water, 29,300 cubic yards, at 50 cents per cubic yard	14,650 00
Contingencies, such as examinations and surveys, superintendence, clerks, office hire, watchmen, &c., &c.	16,000 00
	132,665 56

And the above estimate is supposed to be ample to insure the full permanent improvement of which the locality is susceptible, and to secure a depth of water from 13 to 14 feet at mean low water.

To comply with the terms of a "joint resolution in relation to surveys and examinations of rivers and harbors," approved July 27, 1868, I have to submit the following, as collected from gentlemen of standing who are well acquainted with the subject, and containing all the information which can be immediately obtained.

The products of Northern Pennsylvania reach this harbor by the Delaware and Hudson Canal, and almost the entire products of Delaware and Ulster Counties find their way to market through this outlet.

Bluestone flagging, lime, cement, anthracite coal, lumber, wood, lead, iron, and glass are the exports.

Vessels from all parts of the coast discharge and load at this harbor.

As an illustration of the amount of commerce and navigation to be benefited by the improvement of the harbor, it is stated that from the 1st to the 15th of November last over 350 foreign vessels arrived for cargo, and during the same period over 800 canal-boats arrived laden. More than 20 steamboats run regularly from this place. Thirty-four schooners and sloops are constantly engaged in carrying bluestone, lime, and wood, and 22 vessels constantly engaged in transporting cement. Besides these there are many transient vessels engaged in the same trade, varying in size from 150 to 400 tons. At present vessels drawing over 12 feet are compelled to load outside the bar, and it is believed that a large increase of trade would be the result of the improvement of the harbor. The amount of commerce and navigation to be benefited by the improvement of navigation would be annually from $70,000,000 to $80,000,000.

This is as near as could be estimated from the data available.

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. Engineers and Bvt. Maj. Gen. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS, U. S. A.,
Chief of Engineers, Headquarters Corps of Engineers,
Washington, D. C.

Q 3.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 5, 1869.

GENERAL: In reply to the communication of the Hon. Z. Chandler, chairman Committee on Commerce of the Senate, dated January 29, 1869, asking your views upon the legislation proposed in Senate bill No. 825, authorizing the construction of a bridge across the East River between New York and Brooklyn, I would beg to state that although the injury to be apprehended from such a structure, in the change of the regimen of the stream arising from the diminution of the water-way by piers, and consequent change of the force and direction of currents and formation of bars, as well as the interruption of commerce, seems to be sufficiently guarded against in section 10 of the act of the legislature of New York, of April 16, 1867, incorporating the New York Bridge Company, (to which reference is made in this proposed bill of the Senate,) which prohibits any structure "which shall obstruct the free and common navigation of the East River, or the construction of any pier in the said river beyond the pier lines established by law," yet as it is not known at this office whether the laws establishing the pier lines are or are not framed so as to insure that no injury shall result by those structures to the harbor of New York, it is recommended that a provision to prevent such injury by the piers of the bridge be inserted in the bill.

And further, the plan and location of the bridge should be subject to the approval of the Secretary of War, and it should not be commenced until he approve the same.

He should be empowered to cause the bridge to be inspected during its construction or at any time thereafter, and if in his opinion the bridge or any part thereof violate the conditions not to obstruct, impair or injuriously modify the navigation of the river, or cause injury to the harbor, he should have authority to remove or modify the same at the expense of the company.

From a memorandum accompanying these papers, giving the heights of some of the largest class of merchant vessels, it would appear that the height proposed for the bridge, one hundred and thirty feet above high tide, would not materially obstruct "the free and common navigation of the river," but how far this height would prove an obstacle to ships of war or access to the navy yard at Brooklyn, are questions upon which the views of the proper naval authorities should be known.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Maj. Gen. J. M. SCHOFIELD,
Secretary of War.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., March 9, 1869.

GENERAL: The act to establish a bridge across the East River provides that it shall be so built as not to obstruct, impair, or injuriously modify the navigation of the river, and prohibits the construction ot the bridge until the plan and location are approved by the Secretary of War.

In order to obtain the requisite information to determine whether the

bridge, when built, will conform to the requirements of the law, I beg leave to recommend that I be authorized to form a board in New York, to consist of Brevet Major Generals Horatio G. Wright and John Newton, and Brevet Major Wm. R. King, to examine and report upon the plan and location of the bridge, the effect it will have upon the navigation of the river, upon its regimen and upon the harbor, and the approaches thereto, whether by Sandy Hook or the East River. The board should be instructed to call upon the company for the plan and map and information they are required to submit. They should also be directed to examine experts, (nautical men and shipping merchants,) as to the obstruction that the bridge may form, owing to the limit of height above the surface of the water, that the question of practicability may render necessary.

I would also suggest that as soon as the necessary information for considering that part of the subject can be furnished by the board, that the views of naval authorities be obtained as to how far the bridge may prove an obstacle to ships of war, or impede access to the navy yard.

Perhaps this opinion can be best obtained by adding a naval officer to the board, in which case the order for organization should emanate from the War Department. In that event it would probably be better to constitute the board as follows: Brevet Major General Wright, a naval officer, and Brevet Major King.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Maj. Gen. J. M. SCHOFIELD,
Secretary of War.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., March 18, 1869.

GENERAL: I submit herewith, for the General of the Army, a communication from Mr. John A. Roebling, engineer and authorized agent of the New York Bridge Company, relative to the bridge across East River.

The papers submitted by Mr. Roebling, (sent herewith,) and those which he promises to furnish as soon as copied, constitute essentially "the plan and map" specified in section 2 of the act relative to the said bridge, and form a sufficient basis for such examination of the subject as may be deemed necessary to enable the Secretary of War to come to a decision upon it.

I would suggest that this matter now be referred to an officer of engineers or a board of engineers, or a board of say two engineers and one navy officer, to examine and report upon the plan and location of the bridge, the effect it will have upon the navigation of the river, upon its regimen, and upon the harbor and approaches thereto, whether by Sandy Hook or the East River. Experts should be examined (nautical men and shipping merchants) as to the extent of obstruction the bridge may prove to be, owing to the limit of height above the surface of the water, that the question of practicability may render necessary.

The views of the naval authorities should be obtained as to how far the bridge may prove to be an obstacle to ships of war or impede access to the navy yard.

A copy of the bill in the shape in which it passed accompanies this letter.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

The ADJUTANT GENERAL,
United States Army.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., May 31, 1869.

SIR: The report, with the accompanying papers of the commission constituted by Special Orders No. 72 from the Adjutant General's Office, to examine and report upon the bridge proposed to be built between the cities of New York and Brooklyn, is herewith respectfully submitted to the Secretary of War.

After an examination of them and a careful consideration of the subject, the conclusion at which I have arrived is that the proposed bridge, if built subject to the conditions recommended by the commission, with the prescribed height in the middle, of one hundred and thirty feet above mean high water of spring tides, will conform to the requirements of the act of Congress "not to obstruct, impair, or injuriously modify the navigation of the river," and I recommend to the Secretary of War approval of the same.

The phrase in the act of Congress "not to obstruct, impair, or injuriously modify the navigation of the river," was prepared by myself, and with reference to the meaning attached to those words by the best authorities, and they were, I believe, used in the act with that understanding of them.

I would further recommend that the bridge company be furnished with a copy of the report of the commission.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

Hon. JNO. A. RAWLINS,
Secretary of War.

NEW YORK, *May* 22, 1869.

GENERAL: The commission constituted by Special Orders No. 72, from the Adjutant General's Office, to examine and report upon the bridge proposed to be built between the cities of New York and Brooklyn, by the New York Bridge Company, having completed the investigation of the subject, has the honor to submit the following

REPORT.

The questions submitted in the instructions from the War Department for investigation by the commission are taken up in order:

1st. To "report upon the plan and location of the bridge, and the practicability of the structure."

It should be stated that the bridge company furnished the commission with drawings, exhibiting the plan and location of the proposed bridge,

and copies of estimates and other papers relating to the construction, which tended to assist and diminish the labors of the commission in its investigation. The company also presented certain modifications proposed, but not yet officially adopted, consisting essentially in an increase of the width of roadway, from eighty to eighty-four feet; in an enlargement of the steel wire cables to a diameter of fifteen inches, and a consequent increase in the sustaining power of the bridge; in reducing the number and positions of the sliding joints introduced to allow of the expansion and contraction resulting from changes of temperature, and certain other modifications of details to adapt them to the increased width.

As will be seen from the accompanying maps and drawings, the bridge is to commence on the Brooklyn side, at a point near the intersection of Sands and Fulton streets, and to terminate at a point on Chatham street in New York opposite to the "Hall of Records."

The principal dimensions of the bridge, as presented in the plans, are as follows:

	Feet.
Length of approach on New York side, from terminus to centre of tower	2,381
Length of approach on Brooklyn side, from terminus to centre of tower	1,881
Length of river span, from centre to centre of towers	1,600
Total length	5,862
Total width, according to proposed modification	84
Clear height of river span, at centre, above high water	130
Clear height of river span, at towers, above high water	112
Grade of approach, on the New York side, per 100 feet	3.44

The mode of sinking the foundations for the towers, and the plan for erecting the superstructure, have been carefully examined and are believed to be entirely practicable, while in regard to the stability of the structure, when completed, no doubts are entertained; nor, in the opinion of the commission, need any danger be apprehended for an indefinite period of time, (if repairs and preservation are properly attended to,) of an entire or partial destruction of the bridge, either from passing loads or high winds, excepting possibly in the event of a tornado of such violence as to destroy a large portion of the buildings in its track, the power of which cannot be submitted to calculation; such a contingency is however so remote as not to be worthy of serious consideration.

It may be stated in this connection that, contrary to the common opinion, great magnitude in a properly proportioned structure of this kind is an important element of safety against accidents resulting from high winds, since the weight and resistance to oscillation increase in a greater ratio than the surface exposed to wind action.

It also appears that the ratio of the greatest possible moving load to the weight of the structure constantly diminishes as the span increases. For example, in a span of one hundred feet, the greatest moving load might be equal to twice the weight of the superstructure itself, while in a span of sixteen hundred feet, it would be less than one half of that weight; of course the deflection and oscillation, or undulation due to the moving load, would diminish in similar ratio.

2d. "What effect the piers and tower foundations and abutments will have upon the navigation of the river, upon its regimen and upon the approaches to the harbor of New York."

In relation to this question the opinion of the commission is very de-

cided. The towers being within the lines established by the State of New York beyond which no pier or wharf can be extended, can have no sensible influence upon the navigation of the East River, or upon its regimen or upon the approaches to the harbor of New York, beyond what the piers or wharves, as now authorized, occasion.

3d. "To what extent the bridge will obstruct or interrupt the passage of vessels, and the free access to the United States navy yard at Brooklyn."

To the answer to the third question the commission has given much attention, and it has indeed occasioned by far the largest part of its labors.

So far as relates to the free access to the navy yard at Brooklyn, the commission, after a personal interview with Rear-Admiral Godon, commanding at the yard, addressed him a communication, a copy of which is with the accompanying papers, asking the effect which the proposed bridge would have upon the free access of government vessels to the navy yard. His reply, which is also furnished, shows that so far as the naval interests connected with the yard are concerned, the proposed bridge should not be deemed an obstruction.

As regards vessels in the merchant service, the commission has examined shipping merchants, nautical men, and other experts, as directed in the War Department instruction, and has made personal examinations of shipping, wharves, dry docks, and other matters having relation to the subject committed to its consideration. Applications were also made to the Chamber of Commerce, to the Ship-owner's Association, and to the Vessel-owners and Captains' Co-operative Association, all of which are recognized organizations in New York, having in charge the various commercial interests they represent, and whose responses are furnished with the accompanying papers. Of these the two latter, and many of the property owners, warehousemen, and merchants, oppose the construction of the bridge, on account of the alleged injury to commerce and property connected therewith, arising from want of sufficient height above the water to permit the passage under it of vessels of the largest class, with all their spars standing; the striking of which would involve a cost which they maintain would be seriously detrimental to the various interests involved. The drawings presented by the two associations named show that ships of a certain class can pass the bridge only by striking all their spars above the main-topmast; and the expense of this work, which it is alleged cannot be done by the regular crews, but must be done by riggers especially employed for the purpose, as well as the detention to the vessel occasioned thereby, they estimate will impose a serious tax upon commerce.

So far as the striking of the higher spars of large vessels is necessary, just so far the bridge, at its proposed height, "will obstruct or interrupt the passage of vessels," but the vastly larger proportion of vessels frequenting the East River, embracing sloops, schooners, brigs, barks, steamers of all kinds, and ships of the smallest class, may pass under the bridge without obstruction or interruption, with all their spars standing.

4th. "Such other facts and views as may be found to have an important bearing upon the question, whether the said bridge, when built, will conform to the prescribed conditions of the act of Congress relating to it."

This portion of the instructions is the only one which has occasioned any embarrassment, and it turns entirely upon the construction to be given to the act of Congress requiring that the bridge shall not "obstruct"

the navigation of the river. If this word is to be taken in its strictest sense—that the bridge shall offer no impediment whatever to the free passage of vessels of any class; shall impose no necessity of sending down or disturbing their loftiest spars—then the bridge is inadmissible under the terms of the act. The members of the commission do not pretend to such knowledge of law as to claim for their opinion a weight which should decide the question, but taking the cases of other bridges which have been authorized, in which the height decided upon was such as to require preparations for passing similar to those which will be indispensable in this instance, and assuming that Congress, when passing this act, was aware that many sea-going ships carried spars reaching far more than one hundred and thirty feet above the water line, we are of opinion that it was not the intention to use the word "obstruct" in its strictest sense, but to imply by it that the bridge should not present a serious obstacle to the passage of vessels. As has been stated, a large proportion of the shipping frequenting the harbor of New York, whether considered in reference to tonnage or number of vessels, will pass the bridge absolutely without impediment, with all their spars standing. Should the necessity therefore for striking the spars of certain vessels be construed as constituting the bridge an obstruction? In the judgment of the commission it should not; though it feels bound to distinctly present the question for the decision of the War Department.

While the commission feels compelled to adopt the foregoing construction of the law, yet the members feel it their duty to place upon record their opinion as to the proper height, which under all the circumstances should be established for the bridge. An addition of five to ten feet to the present height would permit almost every vessel submerged to half-load line—advantage being taken of the time of tide—to pass with top-gallants standing. The light spars only above the top-gallant would be sent down. This is shown by the following table prepared from the data supplied by the ship-owners' association, fixing the heights of the top-gallant masts above the water-line.

Name of ships.	Height when light.		Height when loaded.		Height at half load line.		Tonnage.
	ft.	*in.*	*ft.*	*in.*	*ft.*	*in.*	
Hudson	137		125	6	131	3	1,801
Palestine	142	6	131		136	9	1,751
Amazon	141	6	131	6	136	6	1,750
J. C. Calhoun	142		129	6	135	9	1,865
N. B. Palmer	126		116	9	121	3	1,124
Constellation	137	3	125	3	131	3	1,534
Mercury	129		119		124		1,156

The rise and fall of tides to be applied to this table is four feet six inches—this being the difference of level between mean high water of spring tides and mean low water.

It should be remarked that while most ships have their masts above the top-mast in one stick, at a slight expense the top-gallants could be fidded, to allow the royals and all above to be sent down or housed, without disturbing the top-gallants.

While all the members of the commission fully recognize the desirableness of giving additional height to the bridge, and while two of them recommend that this condition be required of the bridge company, the third member is of the opinion that the grade of the approaches upon the New York side will not admit of sensible increase, and for this reason, is not in favor of prescribing additional height for the bridge.

As connected with the original question of the bridge, and as directly bearing upon the point now under consideration, the commission would invite attention to the communication from the Chamber of Commerce in favor of the bridge, in which the opinion is expressed that the inconvenience of striking the upper spars should be cheerfully borne by shipping and commercial interests, in view of the advantages which other important interests would derive from its construction; to the papers submitted by the bridge company in reply to the objections presented by the opponents of the bridge; and to the letter of the mayor of New York advocating its construction in view of the advantages which would result therefrom to the city of New York and the surrounding country.

In the conclusions to which the commission has arrived, the relation of the various interests involved has not been taken into consideration as it was not required by the strict letter of the instructions from the War Department. As it might, however, be considered as being within the general scope of those instructions, it may not be amiss to remark that the commission has been convinced by its examination of the subject that a bridge over the East River is rapidly becoming a necessity; that its construction will furnish facilities of communication already required by the population of New York, Brooklyn, and vicinity.

Should it be decided to allow the bridge to be built, the commission recommends that the following conditions be insisted on, viz:

1. That the dimensions and coefficients of stability of the various parts of the structure shall not be reduced below those represented in the papers submitted to the commission.

2. That the center of the main span shall under no conditions of temperature or load be less than the prescribed height in the clear, above mean high water of spring tide, as established by the United States Coast Survey.

3. That no portion of the grillage or enrockments of the pier or tower foundations above the natural river bed shall project beyond the pier lines, as established by the laws of the State of New York.

4. That no guys or stays shall ever be attached to the main span of the bridge, which shall hang below the bottom chords thereof.

The conclusions of the commission may be recapitulated as follows:

1. That there is no doubt of the entire practicability of the structure, nor of its stability when completed.

2. That no sensible effect will be produced by the pier or tower foundations and abutments (towers) upon the navigation of the river, upon its regimen, nor upon the approaches to the harbor of New York.

3. That the bridge will not offer any important impediment to the free access of naval vessels to the United States navy yard at Brooklyn, nor any obstruction or interruption to the passage of merchant vessels under it, further than requiring the larger and more numerous class of ships to send down or house their royals, and in some cases their top-gallant masts.

4. That the bridge as proposed will conform to the prescribed conditions of the act of Congress relating to it, unless it be decided that the word "obstruct or impair" implies that it shall not necessitate any such preparation for passing it, on the part of vessels of the larger class, as is involved in the housing or sending down of top-gallant masts, royal or sky-sail masts.

5. Conditions recommended to be insisted on, in case it should be decided to permit the construction of the bridge. (See concluding paragraphs of report.)

The papers accompanying this report are enumerated in the list herewith.

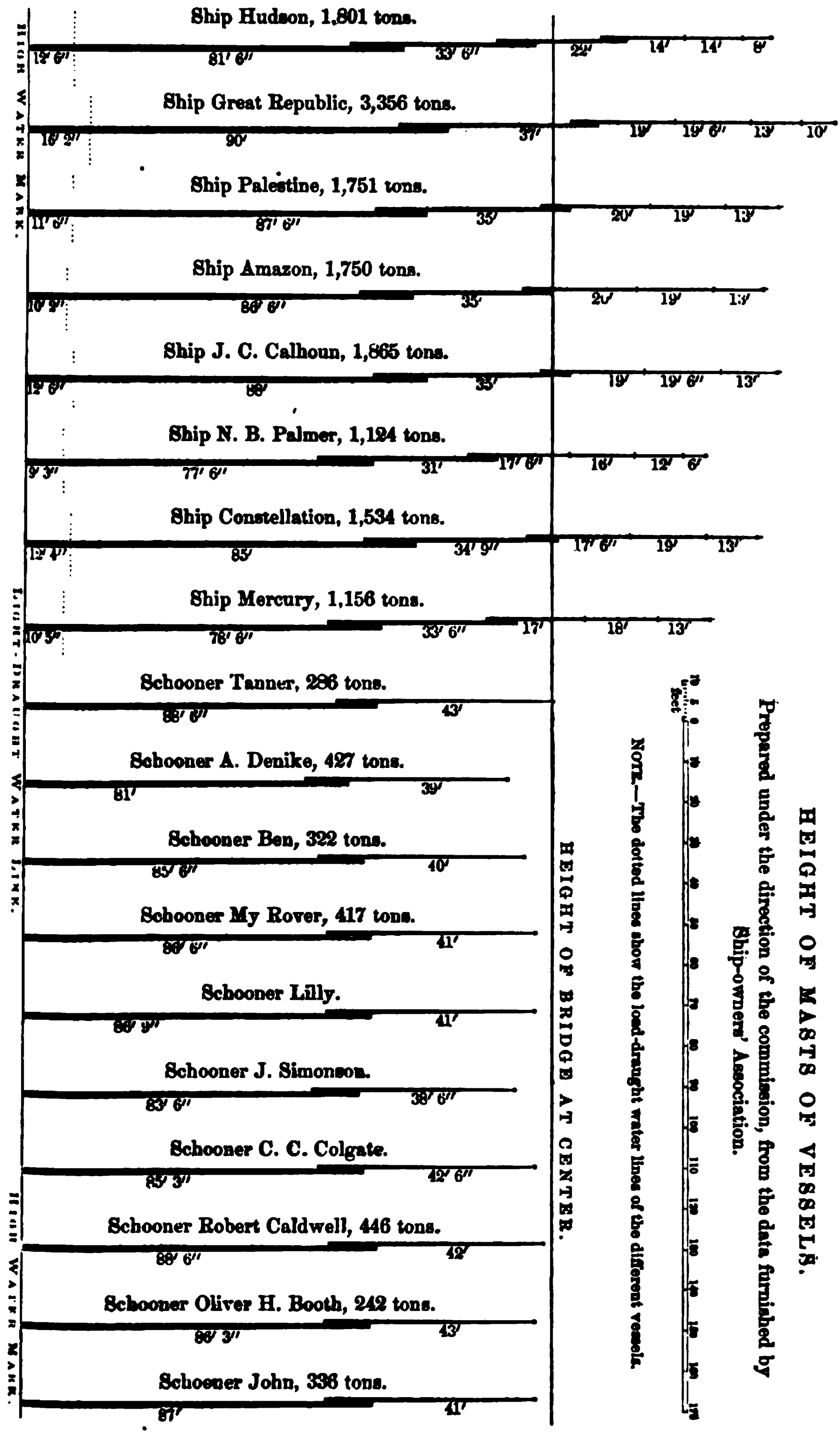
Respectfully submitted.

H. G. WRIGHT,
Lieut. Col. of Engineers, Bvt. Maj. Gen.
JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen.
W. R. KING,
Captain of Engineers, Brevet Major.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

List of papers, maps and drawings inclosed with report of East River Bridge Commission.

1. Maps, drawings and papers from Mr. Roebling, A.
2. Letter to Admiral G. W. Godon and reply, B.
3. Papers from Samuel B. B. Nowlan, C.
4. Papers from George W. Dow, D.
5. Papers from Chamber of Commerce, E.
6. Papers from ship-owners' association, F.
7. Papers from Henry C. Murphy, G.
8. Papers from A. Oakey Hall, H.
9. Papers from Engineer Department, I.
10. Diagram of mast of vessels, J.



HEIGHT OF MASTS OF VESSELS.

Prepared under the direction of the commission, from the data furnished by Ship-owners' Association.

[PUBLIC—No. 53.]

AN ACT to establish a bridge across the East River between the cities of Brooklyn and New York, in the State of New York, a post road.

Be it enacted by the Senate and House of Representatives of the United States of America, in Congress assembled, That the bridge across the East River, between the cities of New York and Brooklyn, in the State of New York, to be constructed under and by virtue of an act of the legislature of the State of New York, entitled "An act to incorporate the New York Bridge Company for the purpose of constructing and maintaining a bridge over the East River between the cities of New York and Brooklyn," passed April sixteenth, eighteen hundred and sixty-seven, is hereby declared to be, when completed in accordance with the aforesaid law of the State of New York, a lawful structure and post road for the conveyance of the mails of the United States: *Provided*, That the said bridge shall be so constructed and built as not to obstruct, impair or injuriously modify the navigation of the river; and in order to secure a compliance with these conditions, the company, previous to commencing the construction of the bridge, shall submit to the Secretary of War a plan of the bridge, with a detailed map of the river at the proposed site of the bridge, and for the distance of a mile above and below the site, exhibiting the depths and currents at all points of the same, together with all other information touching said bridge and river as may be deemed requisite by the Secretary of War to determine whether the said bridge, when built, will conform to the prescribed conditions of the act, not to obstruct, impair, or injuriously modify the navigation of the river.

SEC. 2. *And be it further enacted*, That the Secretary of War is hereby authorized and directed, upon receiving said plan and map and other information, and upon being satisfied that a bridge built on such plan, and at said locality, will conform to the prescribed conditions of this act, not to obstruct, impair, or injuriously modify the navigation of said river, to notify the said company that he approves the same; and upon receiving such notification the said company may proceed to the erection of said bridge, conforming strictly to the approved plan and location. But until the Secretary of War approve the plan and location of said bridge, and notify said company of the same in writing, the bridge shall not be built or commenced; and should any change be made in the plan of the bridge during the progress of the work thereon, such change shall be subject likewise to the approval of the Secretary of War.

SEC. 3. *And be it further enacted*, That Congress shall have power at any time to alter, amend, or repeal this act.

Approved March 3, 1869.

DEPARTMENT OF STATE,
Washington, April 1, 1869.

A true copy.

R. S. CHEW, *Chief Clerk.*

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., May 31, 1869.

SIR: The report with accompanying papers of the commission constituted by Special Orders No. 72, from the Adjutant General's Office, to examine and report upon the bridge proposed to be built between the cities of New York and Brooklyn, is herewith respectfully submitted to

the Secretary of War. After an examination of them, and a careful consideration of the subject, the conclusion at which I have arrived is, that the proposed bridge, if built subject to the conditions recommended by the commission, with the prescribed height in the middle of one hundred and thirty feet above mean high water of spring tides, will conform to the requirements of the act of Congress, "not to obstruct, impair, or injuriously modify the navigation of the river," and I recommend to the Secretary of War approval of the same.

The phrase in the act of Congress "not to obstruct, impair, or injuriously modify the navigation of the river" was prepared by myself, and with reference to the meaning attached to those words by the best authorities; and they were, I believe, used in the act with that understanding of them.

I would further recommend that the bridge company be furnished with a copy of the report of the commission.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

Hon. JOHN A. RAWLINS,
Secretary of War.

[Indorsement.]

WAR DEPARTMENT, *June* 19, 1869.

Respectfully returned to the Chief of Engineers, whose views and recommendations, as well as those of the commission herein referred to, are concurred in and approved; provided, that the height of the center of the main span of the bridge shall not be less than one hundred and thirty-five feet in the clear, at mean high water of the spring tides, and provided further that the structure shall conform in all other respects to the conditions recommended by the commission.

The Chief of Engineers will furnish the bridge company with a copy of the act establishing the bridge, a copy of the report of the commission and of this report, and will notify the company that the plan and location of the bridge are approved, subject to the conditions herein imposed.

JNO. A. RAWLINS,
Secretary of War.

Q 4.

UNITED STATES ENGINEER OFFICE,
HOUSTON, CORNER GREENE STREET,
New York, October 14, 1869.

GENERAL: I have the honor to present the following report of the operations for the removal of the wreck of the steamship Scotland, situated in the south channel of New York Harbor, near Sandy Hook, New Jersey, for the fiscal year ending June 30, 1869:

REPORT.

In accordance with letter of August 1, 1868, from Headquarters Corps of Engineers, informing me that one hundred thousand dollars had been appropriated by Congress for the removal of the wreck of the steamship Scotland, and placing me in charge of the work, I advertised under date of August 5, 1868, for proposals for removal of the wreck.

The contract was awarded on the 5th September, 1868, to the Neptune Submarine Company of New York City, the lowest bidders, for the sum of $63,300, and all the rights of the United States to the vessel and cargo, as per abstract of proposals herewith, to which is attached a copy of the advertisement; the wreck to be removed by the 1st December, 1869. This company entered into contract on the 9th of September, giving bonds for $30,000 of same date, for its faithful performance.

The company commenced operations on the 22d of September and made various reports of the progress of the work, and having notified me that they were ready for a survey of the first section of the wreck, I dispatched on the 13th April, 1869, the United States engineer steamer belonging to the fort at Sandy Hook, with competent surveyors and submarine divers under charge of my assistants at this office. The result of this survey, which occupied several days and was very accurately made, although not allowing of the payment of the contractors for the removal of the first section of the wreck, was satisfactory and demonstrated the fact that real progress had been made upon several portions of the wreck. The process used, that of exploding gunpowder confined in strong kegs, the charges being placed near the part to be detached, has to this period proved efficient.

Respectfully submitted.

JOHN NEWTON,
Lieut. Col. Engineers and Bvt. Maj. Gen. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

NOTE.—The first section of the wreck has been removed and paid for since the commencement of this fiscal year.

FINANCIAL STATEMENT.

Amount appropriated by Congress as per letter from Headquarters Corps of Engineers, August 1, 1868	$100,000 00
Expended during the fiscal year ending June 30, 1869	940 86
Amount available June 30, 1869	99,059 14

UNITED STATES ENGINEER OFFICE,
No. 27 WEST HOUSTON STREET,
New York, August 5, 1868.

Sealed proposals will be received at this office until 12 noon of Saturday, September 5, 1868, for the removal of the wreck of the steamer Scotland, situated in the South Channel, near Sandy Hook, New Jersey.

The wreck and all material pertaining to the vessel must be removed to a depth of at least twenty-two and one-half feet mean low water, and no portion shall again be deposited, after removal, below high-water mark. The work must be completed by December 1, 1869.

The wreck will be divided into three sections by dividing the space from the bow to the stern into three equal portions. When the first section, beginning at the bow, has been removed to the prescribed depth, and according to the foregoing conditions, one-quarter of the stipulated price for the removal will be paid; when the second section has been removed, one-quarter of the price, as above, will be paid; and when the third section has been removed, the balance of the stipulated

sum will be paid; provided, that the work shall be prosecuted and finished in the order above given.

Proposals must state, first, the sum in money asked for the removal of the wreck, the contractor receiving nothing from the proceeds of the material and cargo removed; second, the sum in money asked, the United States waiving in favor of the contractor all its interest in the proceeds of the material and cargo removed.

Proposals to be accompanied by a guarantee of two responsible persons that the bidder will execute a contract.

The proposals and guarantee will be of the form to be obtained at this office.

No bids exceeding one hundred thousand dollars will be entertained.

JOHN NEWTON,
Lieut. Col. of Engineers and Bvt. Maj. Gen. U. S. A.

Abstract of proposals received in answer to advertisement dated August 5, 1868, *for removing the wreck of the steamer Scotland, situated in the South Channel, near Sandy Hook, New York Harbor, opened at* 12 *o'clock, noon, of September* 5, 1868.

Number indorsed on back of bid.	Name of bidder.	For removal of wreck.	For removal of wreck, with rights of the U. S. to cargo and materials.	Remarks.
1	John Flanagan	....	$90,000 00	
2	1. Neptune Submarine Company, by Joseph Hays, president	$83,300 00	....	
3	2. Neptune Submarine Company, by Joseph Hays, president	....	63,300 00	
4	George E. Lincoln	84,600 00	82,650 00	
5	The Coast-Wrecking Company, by Charles Dennis, chairman	140,000 00	95,000 00	
6	New York Submarine Company, by S. Samuels, president	89,500 00	87,000 00	
7	E. F. Folger & Co	99,000 00	97,740 20	This bid is informal and unintelligible.
8	William P. Coe	84,500 00	80,000 00	This bid is informal.
9	C. H. Mallison	74,500 00	72,000 00	Do. do.
10	John Waters, per William V. A. Mulhallon	67,250 00	65,000 00	Do. do.
11	George W. Beardslee	89,000 00	79,000 00	
12	Received, Monday, September 7, 1868; two days too late, and still unopened	....	....	

I certify that the above abstract is correct.

JOHN NEWTON,
Lieut. Col. Engineers, Bvt. Maj. General U. S. A.

APPENDIX R.

ENGINEER OFFICE UNITED STATES ARMY,
Newport, R. I., August 27, 1869.

GENERAL: In compliance with circular, dated Office Chief of Engineers, Washington, D. C., June 12, 1869, I have the honor to submit the following annual report of progress on the works of river and harbor improvements and surveys in my charge for the year ending June 30, 1869:

IMPROVEMENT OF PAWTUCKET RIVER, RHODE ISLAND.

The operations on this river have been confined to dredging the channel to the extent permitted by the balance of the appropriation, viz., $457 50.

To complete the work deemed necessary for the completion of the work on this river, viz., dredging to obtain a channel six feet deep at mean low water, the sum of $15,000 is estimated.

In regard to the points specially called for by the circular, I have the honor to report as follows:

2d, $15,000; 3d, $15,000; 4th, Providence district; 5th, Providence, Rhode Island; 6th, $184,520 30; 7th, same as previously reported; 8th, none; 9th, none; 10th, none;

11th, on hand June 30, 1868	$357 50
Cash received during the fiscal year ending June 30, 1869	....
	357 50
Cash expended during the fiscal year ending June 30, 1869	457 50
Due from the United States June 30, 1869	100 00
Amount in treasury June 30, 1869	$100 00
Available June 30, 1869	....
Amount required for year ending June 30, 1871	15,000 00

IMPROVEMENT OF PROVIDENCE RIVER, RHODE ISLAND.

No work has been done on this river during the year. It is estimated that the sum of $10,000 is needed for the further improvement of this river, as explained in my annual report, dated August 8, 1869.

In regard to the points especially called for by the circular, I have the honor to report as follows:

3d, $10,000; 4th, Providence district; 5th, Providence, Rhode Island; 6th, $184,520 30; 7th, same as previous reports; 8th, 9th, and 10th, none; 11th, no cash received or expended during year.

Amount required for year ending June 30, 1871	$10,000 00

IMPROVEMENT OF THAMES RIVER, CONNECTICUT.

The operations on this river have consisted in dredging the channel immediately below Norwich, so as to obtain a depth of fourteen feet at high water.

The work, it is expected, will be completed the present season, and a sufficient balance will be left to enable an examination to be made next season for the purpose of ascertaining the effect of the work.

No estimate is submitted for the fiscal year ending June 30, 1871.

In regard to the points especially called for by the circular, I have the honor to report as follows:

4th, third collection district of Connecticut; 5th, New London, Connecticut; 6th, ———; 7th, same as in previous reports; 8th, 9th, and 10th, none during the year;

11th, on hand June 30, 1868	$5,942 46
Cash received during fiscal year ending June 30, 1869	25,000 19
	30,942 65
Expended during fiscal year ending June 30, 1869	29,662 59
	1,280 06

Amount in treasury June 30, 1869	$20,000 00
	21,280 06
Less amount withheld in accordance with contract for dredging until completion of work	5,972 13
Available June 30, 1869	15,307 93
Amount required for the year ending June 30, 1871	....

SURVEY OF CONNECTICUT RIVER FROM HARTFORD TO ITS MOUTH.

I made an examination of the bar at the mouth of this river in July, 1868, and the result is exhibited on the accompanying sketch. It is estimated that, in order to secure a depth of eight feet at mean low water on this bar, one hundred feet in width, it will be necessary to remove a prism of five thousand cubic yards.

It is certain that no permanent results would be obtained here by dredging, but it is probable that this depth could be maintained by the periodical use of a scraper.

No amount is estimated for this work beyond that offered in previous reports, viz., $70,000, as the improvements most needed on this river are the removal of the bars and protection of the banks below Hartford, detailed in my report, dated January 11, 1868.

In regard to the points especially called for by the circular, I have the honor to report as follows:

2d, $70,000 is requested to excavate a channel two hundred feet wide and eight feet deep at low water, and an annual appropriation of $10,000 to maintain it; 3d, $70,000; 4th, Middletown district; 5th, Middletown, Connecticut; 6th, $18,848 49; 7th, same as previous reports; 8th, 9th, and 10th, none during the year;

11th, amount expended during the fiscal year ending June 30, 1869, from appropriation for "examinations and surveys on the Atlantic coast"	$229 06
Amount required for the year ending June 30, 1871	70,000 00

REMOVAL OF MIDDLE ROCK, NEW HAVEN HARBOR, CONNECTICUT.

The work on this rock was suspended on the 21st of September, 1867, owing to the appropriation being nearly exhausted. The results of the survey were communicated to the department in my report, dated January 28, 1868. To complete the removal of this rock to the depth originally proposed I have estimated $10,000.

The complete removal of the obstructions at the mouth of this harbor requires not only the removal of Middle Rock, but also that of Southwest Ledge, and two rocks intermediate between the two, and any plan for the improvement of the harbor should contemplate the removal of all these. On the Southwest Ledge there is six and a half feet at low water, and on the other rocks thirteen feet and fourteen feet, respectively.

The total amount now estimated for removing these rocks is $65,000.

In regard to the points especially called for by the circular, I have the honor to report as follows:

1st, removal, by blasting, to a depth of seventeen feet at low water; 2d, Middle Rock, $10,000; Southwest Ledge, $30,000; intermediate

rocks, $25,000; total, $65,000; 3d, $30,000; 4th, New Haven district; 5th, New Haven; 7th, same as previous reports; 8th, 9th, and 10th, none during the year;

11th, amount on hand and available June 30, 1868	$250 56
Available June 30, 1869	250 56
Amount required for the fiscal year ending June 30, 1871..	30,000 00

SURVEY OF BRIDGEPORT HARBOR, CONNECTICUT.

A resurvey of this harbor was made last year, in compliance with instructions from the Chief of Engineers, dated Headquarters Corps of Engineers, Washington, April 20, 1868.

No plan was submitted for any works for the improvement of this harbor.

In regard to the points especially called for by the circular, I have the honor to report as follows:

11th. Amount expended during the fiscal year ending June 30, 1868, from appropriation for examinations and surveys on the Atlantic coast	$1,208 28

IMPROVEMENT OF WESTPORT HARBOR, CONNECTICUT.

Nothing has been done in this harbor, as the appropriation, $2,500, is entirely insufficient to accomplish the improvement desired.

An additional amount of $10,000 is estimated for the completion of the work.

In regard to the points especially called for by the circular, I have the honor to report as follows:

2d, $10,000; 3d, $10,000; 4th, Fairfield, Connecticut, district; 5th, Bridgeport, Connecticut.

11th. On hand June 30, 1868...........................	$610 66
Cash received during the fiscal year ending June 30, 1869..	3 99
	614 65
Expended during fiscal year ending June 30, 1869........	74 75
	539 90
Amount in treasury	1,550 00
Amount available June 30, 1869	2,089 90
Amount required for the year ending June 30, 1871	$10,000 00

PLYMOUTH BEACH, MASSACHUSETTS.

The sum of $76 61 was transferred to me on June 1, 1869, by Brevet Major J. A. Smith, Corps of Engineers, being the balance on account of the appropriation for "repairs of harbors on the Atlantic coast," applicable to the improvement of this beach.

The following is a copy of a statement furnished me by Major Smith, of the operations during the last fiscal year:

In the summer of 1866 nearly $8,000 was expended in the construction of new work and in repairs. Other work was added by the State in 1867, at an expense of about $2,000. These works were then deemed sufficient to resist any action of the sea, but a

storm in the autumn of 1867 carried away some of the more exposed portions, and a second occurring the subsequent winter, when tides were highest, carried away about a thousand linear feet of the strongest portion of the work, besides doing other damage, leaving the northern portion of the beach, adjacent to the main entrance of the harbor, entirely unprotected from the open sea, save by some remaining portions of a work completed in 1832, and the beach itself so much reduced as to be entirely submerged at extreme high tides for a length of one thousand five hundred feet. The sand was such that while a slight action of the sea would raise the beach, the prevailing winds and heavier seas would drive the sand into the channel, and it was evident that a severe storm would not only seriously injure the beach thus unprotected, but also the main channel, and leave it entirely exposed to further encroachments.

On the last of August, 1868, a letter was received from the Engineer Bureau, giving information that about $7,000 would be made available for expenditures upon the beach. It was considered absolutely essential to do as much as possible before the fall and winter storms set in.

Advertisements were issued for proposals for building the work. One class to be a substantial crib-work of timber, covered with plank and filled with stone; the other to be the old triangular work.

No proposals were received until past the middle of September. Two proposals only were received, both of which were rejected, as they were deemed too high, with the further reason that it would be nearly impossible to complete contracts in time to do the work before winter would compel its suspension. Lumber was immediately ordered for the work, and a small force employed until the arrival of further materials. Adverse winds detained the lumber (from Bangor, Maine) nearly three weeks, so that no very active operations could be commenced until the middle of October. A vessel and crew was then hired to freight ballast for the cribs, and after being several days out without doing anything, was lost in a storm. Other vessels were employed, but the prevalence of storms and winds made progress both slow and expensive. Two hundred linear feet of substantial crib-work of timber, covered with plank and filled with stone, were completed, the crib being placed in a trench about two feet deep, and the plank on the seaward side being driven deep to prevent the sea from undermining the work. One crib one hundred feet in length was placed in position, but a storm in the night, before it could be loaded, drove it away and lost some of the timber. One hundred and seventy-six linear feet of triangular work, similar to that before used, were completed in a trench three and a half feet deep, and filled with sand.

A break in the old work, fifteen linear feet, was filled with solid timber triangles and filled with stone; and one hundred linear feet of work consisting of posts set four feet deep, covered both sides with plank two feet high. One entire crib one hundred feet long was framed and a second partly done, which could not be put in position owing to the unusual inclemency of the season and the attendant expense. For this reason considerable material was left which could not be utilized.

Through the courtesy of Mr. Leavitt Robbins, of whom the timber was purchased, the timber and tools were allowed to remain upon his premises, with the understanding that any expense or trouble to himself would be reimbursed in case of future appropriations.

On the 30th of June, 1869, I visited Plymouth and examined the beach, finding the works for its preservation in an unfinished condition, and the beach greatly exposed to the action of the sea.

I will submit as early as practicable a project and estimate for the preservation of this beach, upon which depends the existence of the harbor of Plymouth.

I inclose herewith abstract of proposals, with names of bidders, for this work.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Maj. of Engineers, Bvt. Col. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

Abstract of proposals for construction of breakwater at Plymouth beach, Mass.

Proposals.	Names of bidder.	Price proposed.
Class No. 1.		
For constructing breakwater on Plymouth beach, Mass	Gideon Currier	$15,730 for 1,000 feet.
Do	J. Gifford	$20 36 per foot.
Class No. 2.		
For constructing breakwater on Plymouth beach, Mass	Gideon Currier	$9,000 for 1,000 feet.
Do	J. Gifford	$9 03 per foot.

D. C. HOUSTON,
Major of Engineers, Bvt. Colonel U. S. A.

R 1.

ENGINEER OFFICE UNITED STATES ARMY,
Newport, Rhode Island, January 23, 1869.

GENERAL: I have the honor to submit herewith a tracing, giving the hydrography of Bridgeport Harbor, Connecticut, from a survey made during the past season; also a report of Captain A. H. Holgate, United States engineers, in relation to the harbor.

From this map and report, and careful study of the changes going on in the harbor, I do not find it necessary to recommend at this time the construction of any works for the improvement of this harbor.

The channel and harbor facilities are essentially as good as is shown by the survey of 1837. The channel, at its present depth, is an artificial one made by dredging. That it remains unchanged as to depth is evidence that no serious injury has been sustained. It will be time enough to expend money for the improvement of this harbor when the channel is found to be inadequate to the necessities of commerce, and then dredging must be resorted to.

The construction of groins on the beach to the east of the harbor, referred to in Captain Holgate's report, would check the movement of sand by the flood tide, until the intervening spaces were filled up, but I would not recommend their construction until the necessity is more apparent than at present.

The construction of a breakwater at the mouth of the harbor, on the line A B, survey of 1868, as has been suggested, would contract the water-way, and effect such changes in the currents as might be of serious injury. I submit, therefore, no estimate for the improvement of this harbor.

It is very doubtful in my mind whether there is any permanent remedy for the evil anticipated by those interested in the harbor. The effect of storms on the sandy bottom of a shoal harbor is necessarily to shift the channel more or less, and if it should be found in future that the channel is not maintained by the action of the tidal current, it will be necessary to excavate it, as was formerly done.

In compliance with Headquarters Circular, dated July 29, 1868, furnishing the "joint resolution of Congress approved July 27, 1868, in relation to surveys and examinations of rivers and harbors," I submit a

copy of a letter from Captain John Brooks, collector of customs at Bridgeport, containing all the facts called for by the resolution.

The object of this resolution is as stated, to prevent the application of the public moneys, excepting where such improvements shall tend to subserve the general commercial and navigation interests of the United States.

The extent to which these general interests will be subserved by any improvement of Bridgeport Harbor is very small; at all events, not sufficient to warrant the expenditure of public money, unless the necessity is urgent and the remedy apparent. The trade there is entirely local. The harbor is not needed as a harbor of refuge, as Black Rock Harbor, a few miles to the westward, is much more accessible and commodious.

The following information, called for by Headquarters Circular, dated June 10, 1868, is submitted:

1st, no essential changes are discovered in the channel since former surveys; 2d, no plan for the improvement has been made, none being deemed necessary at present; 3d, ———; 4th, Fairfield collection district; 5th, New Haven, Connecticut; 6th, $37,945 66; 7th, number of vessels arriving from foreign ports during the fiscal year ending June 30, 1868, 71; tonnage, 9,242; average, 116 tons. Number cleared for foreign ports in same period, 67; tonnage, 8,793; average, 130 tons. Number of arrivals and departures of vessels engaged in coasting trade in same period is estimated at 2,000, tonnage 140,000.

I am, general, very respectfully, your obedient servant,

D. C. HOUSTON,
Major of Engineers, Bvt. Col. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army,
Commanding Corps of Engineers, Washington, D. C.

NEW LONDON, CONNECTICUT,
December 19, 1868.

SIR: In obedience to your order, dated Newport, Rhode Island, August 11, 1868, I have the honor to report that I have visited Bridgeport, Connecticut, as occasion has demanded, and have carefully observed the progress of the survey made by Mr. George Beckwith, surveyor.

This survey has been delayed somewhat, perhaps, because Mr. Beckwith, being city surveyor, cannot find time to attend properly to other duties. Doubtless, also, adverse winds, tides, and the inexperience of his assistants have contributed to retard his progress; I am still awaiting his report.

I have received some useful information from Captain John Brooks, collector of the port at Bridgeport, and have tested, as far as possible, by actual experiments, his opinions and experience of the directions, velocities and results of the tidal currents, both ebb and flood, and have found them almost invariably correct.

The survey of the present year will, I think, show no material change in the depth of the water in the channel leading to Bridgeport Harbor proper, or in the outer harbor, during the past twenty years, or since the survey of Lieutenant Blake.

Experienced pilots and sea-faring men have feared that the harbor of Bridgeport is in danger of being filled up and destroyed. In order to

ascertain how much cause there may be for this apprehension surveys have been made; and besides the several inspections of the harbor and its approaches, experiments have been made to determine the directions and velocities of the tidal currents. I forward herewith a rough sketch of the harbor, upon which is laid down, as nearly as possible, the results of these experiments, in order to render a written description more plain.

The islands at the mouth of Black Rock Harbor (marked A) seem to have been a part of the main land formerly, but were were left in their present state by the breaking through of the sea, probably during a heavy storm. From half ebb to extreme low water they are still connected with the main land by a low sandy beach, (marked B.)

Captain John Brooks seems to be of the opinion that from high flood tide until about half ebb the large body of water filling the extensive creeks and inlets running inland from Black Rock Harbor sweeps over this beach, and turning northerly meets and partially counteracts the powerful current which sweeps out of the Gut channel, (marked C,) and which performs the important office of scouring and keeping open the approaches to the harbor of Bridgeport. Had this idea of Captain Brooks been justified by actual experiment it might have been advisable to shut off this outlet for the waters of Black Rock Harbor. However, this particular tidal current does not run far enough up towards the harbor of Bridgeport to have any material damaging effects, and our attention is therefore directed to other points in order to determine the causes and meet and counteract the effects which have been apprehended. Long Beach (marked D) is very much exposed to the attacks of the sea during all storms coming from the southward, and is composed mainly of loose sand and shells.

The more important of the tidal currents flow about as follows: starting at extreme low water the tide sweeps westwardly on Long Beach, turns abrubtly around the point of the sand spit (marked E) and flows up the Gut, filling all the extensive creeks and inlets leading from the Gut channel.

From about half flood until extreme high tide the water flows into the Gut over the sand spit, and close around the western extremity of Long Beach, (marked F.) From extreme high tide until about half ebb this large body of water pours back through the Gut, sweeping around over the sand spit, and from that time until low water it flows around it and in a direction more towards the mouth of Bridgeport Harbor. It is by this powerful current that the approaches to Bridgeport Harbor are kept open, and it is the loss of this current from the closing up of the mouth of the Gut channel, involving the destruction of the harbor, which is feared.

Careful inspection of the north shore of Long Beach, (marked H,) leads to the conviction that it has remained from year to year essentially unchanged. There is no doubt, however, that the north shore of the Gut channel, (marked H,) opposite Long Beach, is continually wearing away, and it is probable that some portion of the sand is left upon the sand spit. I think, however, that the growth of this sand spit is due mainly to the following cause:

During every gale from the southward, the Long Beach, from Point-no-Point (not shown on the sketch) to its western extremity is exposed to the unchecked action of the waves, which dash in upon it with such terrible effect that at one time within the past few years the sea broke entirely through near Point-no-Point and flowed freely into the Gut channel. Within a comparatively short period afterwards the succeed-

ing storms had carried in sand and filled up this break in the beach, but the spot where it occurred is still plainly marked. To the eastward of Point-no-Point the character of the beach is such that there can be no serious abrasion.

The sand which is washed away by these storms is carried successively by the heavy rollers, as well as by the ordinary action of the flood tide, which sweeps along this beach, further and further toward the western extremity of Long Beach, and is finally deposited upon the sand spit.

I send herewith a sketch of this sand spit, (drawn to a scale of $\frac{1}{5000}$,) which exhibits the low-water mark of 1866, (in black ink,) and that of 1868, (in red ink,) which may aid in forming an opinion as to the nature and progress of the change now going on.

Therefore I believe that the object in view, viz., to guard against the future injury, and perhaps destruction, of the present harbor of Bridgeport will be accomplished, simply by preventing any further growth of this sand spit. This, I think, will be cheaply and effectually done by a few piers or jetties of loose stone or strong rows of piling, at suitable points, (to be hereafter selected,) between Point-no-Point and the western end of Long Beach. I think six of these will be amply sufficient, and they should extend from a little above high-water mark to extreme low-water mark.

The north shore of the Gut channel can be easily secured from further change by a low wall of loose stone, placed somewhat below high-water mark, at the most exposed points, or by enrockments at those points.

I also forward herewith a sketch of the Gut channel, with the various creeks or inlets spoken of, and give below an approximate estimate of the length, depth and width of each, with a view to show as nearly as possible the amount of water stored up by each flood tide to be used during the ebb in scouring the approaches to the harbor.

The difference between high and low water mark is about six feet.

A. *Mill Creek.*—About one-fourth of a mile wide at high water; average depth seven feet; about one-half of a mile in length.

B. *Eagle Nest Creek.*—About one-half of a mile in width; average depth seven feet; about one and one-fourth miles in length.

C. *Preston Creek.*—About three hundred feet wide at high water; average depth about seven and one-half feet; navigable for vessels of sixty tons; length about two miles.

D. This creek is about one hundred feet in width at the mouth, narrowing gradually to its inland extremity; average depth about six feet; length about one-half of a mile, with tributary creeks.

E. About one hundred feet in width at its mouth, narrowing gradually; average depth about seven feet; length about one mile.

F. *Fresh Pond Creek.*—Filling at high tide a wide field of water, rather difficult to estimate. Its length is about one and a half mile, and its average depth is about six feet.

The eastern outlet of the Gut channel then runs through Neck Bridge to Stratford, but a very small portion of this water escapes in this direction. It will be perceived by taking the difference between high and low-water mark that nearly all of this water is poured out through the Gut channel, in the direction of Bridgeport Harbor, during the ebbing of the tide.

Very respectfully, your obedient servant,

A. H. HOLGATE,
Captain Engineers.

Bvt. Col. D. C. HOUSTON,
Corps of Engineers U. S. A.

CUSTOM-HOUSE, BRIDGEPORT,
District of Fairfield, November 19, 1868.

SIR: Your favor of the 14th was duly received, and in answer to the first question I reply:

Question 1. What is the number of the custom district to which Bridgeport belongs?—I am unable to reply precisely. I find in the finance report of 1866, published by the Secretary of the Treasury, it stands No. 33, it is known, however, as the district of Fairfield, of which Bridgeport is the port of entry for the district, but whether the above number is the correct one I cannot tell.

Question 2. What is the nearest port of entry?—The nearest to this is New Haven.

Question 3. What is the amount of commerce and navigation to be benefited by any improvement of the harbor?—The number of vessels arrived in this port of Bridgeport during the fiscal year ending June 30, 1868, from foreign countries was seventy-one; their tonnage amounted to 9,242 tons; the number of vessels cleared for foreign countries during the same period was sixty-seven; their tonnage amounted to 8,793 tons; the value of merchandise imported in the above vessels from foreign countries amounted to $100,000.

The number of vessels arriving and departing, as near as I can ascertain, engaged in the coasting trade or coastwise, during the same period, is about 2,000; their tonnage about 140,000 tons.

The value of the merchandise coming in and going out of the harbor, by this class of vessels, is from $180,000,000 to $200,000,000, when you take into consideration that Bridgeport is the terminus of two important railroads, the Housatonic and also the Naugatuck, the great manufacturing valley. This railroad pays a dividend semi-annually of five per cent. on the stock, leaving a large surplus.

The value of steamboats engaged in the commerce of this place is about $300,000; the value of sail vessels engaged in this coastwise may be estimated at about $6,000,000; these vessels of course are not all owned here, nor in this district.

For the fiscal year ending June 30, 1868, the amount of duties collected from imports	$34, 515 19
Amount of tonnage tax collected	3, 430 47
Total amount paid into the treasury of the United States.	37, 945 66

In making up the above statistics I have endeavored not to overstate, but rather come below the actual valuations, number and valuations of vessels. If there is any other information you may require, it will be a pleasure for me to render you any assistance in my power.

Very respectfully, yours,

JOHN BROOKS,
Collector of Customs.

D. C. HOUSTON,
Col. U. S. A. Engineers.

NOTE.—It is probable that the value of merchandise estimated by Captain Brooks at from "$180,000,000 to $200,000,000" should be stated at from $18,000,000 to $20,000,000, which would correspond more nearly to the means of transportation stated.

D. C. HOUSTON,
Maj. Eng., Brt. Col.

APPENDIX S.

BOSTON, MASS., *September* 8, 1869.

GENERAL: I have the honor to make the following report of progress made in the works of river and harbor improvements under my charge, during the fiscal year ending the 30th of June, 1869, and of the probable progress during the present working season.

IMPROVING HARBOR AT BOSTON.

The dredging at the southwest point of Lovell's Island has been steadily carried on by the contractor, Mr. A. Boschke, with only a short interruption during the winter months. During the fiscal year ending the 30th of June, 1869, 66,909.54 cubic yards of material have been removed; the channel has been widened thereby to about 600 feet at the sixteen-feet curve, and an average depth has been produced, over the dredged area, of 16½ feet at mean low water. A new and powerful machine is now at work to level the ridges on the dredged area and to carry the excavation to the full depth of 23 feet at mean low water, as required by contract and the interests of navigation. At the close of the season it is expected that the width of the main ship channel at this point will be increased to 600 feet, with a least depth of 23 feet at mean low water, thus giving 235 feet more channel-way than previous to the commencement of dredging operations. The total of dredged material removed so far, (June 30, 1869,) amounts to 159,808.54 cubic yards, leaving yet a balance of 217,801.46 cubic yards, according to the original estimate, to be removed. A portion of this, say about 70,000 cubic yards, will probably be removed during the present working season, which will consume the balance of the amount allotted to this work.

At the Upper Middle Bar the contractor made several attempts to carry out his agreement for the removal of 30,000 cubic yards from this bar, with a new and powerful machine expressly built for the purpose. If not entirely successful, he at least practically proved that with this machine he was able to excavate the material of the bar, (hard pan,) to the desired depth. About 450 cubic yards of material have actually been removed; the work is temporarily suspended, and the amount heretofore allotted for this work has been transferred to the works at Lovell's Island.

No further steps have been taken to prosecute the work during the present working season, as it was deemed preferable to use the available funds at the works at Lovell's Island.

Blasting and removing Corwin Rock.—This rock, reported last year as being blasted down to an average depth of 21½ feet at mean low water, has been entirely removed, as also an adjoining ridge of rock to the depth of 23 feet at mean low water. There have been altogether 1,356 tons of rock blasted, 1,192 tons of which were hoisted and deposited on shore, and 164 tons in small fragments were left in deep water along side of the rock. Total number of cubic yards of rock blasted and removed 608¾.

By the removal of Corwin and Lower Rocks, the main ship channel, formerly between these rocks about 250 feet in width, has been widened to over 600 feet.

Blasting and removing Barrel Rock.—A careful survey of this rock has been made, and an agreement entered into for its removal, with Mr. George W. Townsend, the same contractor who successfully removed Lower and Corwin Rocks. The moorings for the vessel from which the

blasting operations will be conducted have been established, and otherwise all the necessary preparations made for immediately commencing work. This rock it is expected will be entirely removed by the 1st of September, when all further operations in this line will be suspended, unless the Chief of Engineers consents to the removal of Kelly's Rock, situated in the main ship channel near the Narrows. This rock, in my opinion, should be removed at once, as its situation is a source of great danger to the navigation of the channel.

Sea-wall at Point Allerton.—Except making some preliminary surveys and investigations having reference mainly to the location of a wharf, nothing could be done, as the question of the title to the land to be occupied by the proposed sea-wall is not yet fully settled.

As soon as the title to the land for the position of the wall (forwarded in January last) has received the approval of the Attorney General of the United States, proposals will be invited for the construction of the same. If this approval can be obtained during this fall, contractors may prepare the stock during the winter, and the work be pushed with vigor early in the spring.

Sea-wall for the preservation of Gallup's Island.—The necessary preparations having been previously made, its construction was taken in hand by the contractor, Mr. James Andrews, in July of 1868, and steadily continued, except during the winter months. A deviation from the general plan had to be made, for a distance of several hundred feet, by lowering the foundation two feet, and adding another course of stone to more effectively guard against the under wash by eddy waves.

The extent of the wall built during the fiscal year ending June 30, 1869, is as follows:

Of foundation, lineal feet	558
Of wall proper, (stone courses,) an average of lineal feet	456
Amount of excavation for above wall, cubic yards	1,369
Amount of filling, (back of wall,) cubic yards	329
Concrete masonry, cubic yards	1,817
Granite masonry, cubic yards	558

It is proposed to continue in force the contract with the present contractor during this working season, and to push the work with vigor so as to complete about 1,100 feet of wall by the end of the season.

Sea-wall for the north head of Long Island.—This work has not yet been commenced.

The county court, upon an act passed by the legislature of the Commonwealth of Massachusetts, has determined upon the amount to be paid to the owners of the land required for the site of this work, and for the military defenses to be erected on Long Island; and the title may be vested in the United States upon deposit of the sum in the hands of the judge of the court.

The papers relating to the case were forwarded, some time since, to Washington; should the title be approved and the money deposited in court during the season, proposals will be invited at once and all necessary preparations made for commencing operations early the ensuing spring.

Amount on hand and in treasury July 1, 1868	$211,234 40

Amount expended during the fiscal year ending June 30, 1869, on the works for the preservation and improvement of Boston Harbor:

For dredging southwest point of Lovell's Island	$40,929 07
For dredging Upper Middle Bar	610 47

For removal of Corwin Rock	$17,965 58
For sea-wall on Gallup's Island	41,358 76
For sea-wall at Point Allerton	543 30
For contingencies, office expenses, expenses of steam-tug, &c	14,420 10
Total amount expended	115,827 28

Amount allotted to this harbor during the year	$116,000 00
Balance remaining on hand, in treasury and sub-treasury, July 1, 1869	211,407 12

Probable amount to be expended during the year ending December 31, 1869:

At Lovell's Island	$40,000 00
At Gallup's Island	40,000 00
For removal of rocks	10,000 00
For contingencies	8,000 00
	98,000 00

Balance probably on hand December 31, 1869, $113,407 12, which will probably be expended before July 1, 1870, as follows:

For sea-wall at Point Allerton	$45,000 00
For sea-wall at Long Island	60,000 00
For contingencies	8,000 00
	113,000 00

Amount required to be appropriated for the fiscal year ending June 30, 1871, a portion of which should be made available for the fiscal year ending June 30, 1870:

For dredging at Lovell's Island, (to complete the work)	$75,000 00
For sea-wall at Gallup's Island, (to complete the work)	60,000 00
For dredging at Upper Middle Bar	100,000 00
For sea-wall at Point Allerton, (to complete the work)	40,000 00
For sea-wall at Long Island	40,000 00
For contingencies	15,000 00
Total for improving harbor at Boston	330,000 00

Amount required for the entire and permanent completion of the works in this harbor, in addition to the amount expended, on hand, and estimated for above:

For the Upper Middle Bar, if the improvement is to be carried to the extent estimated for by the board of harbor commissioners	$100,000 00
For sea-wall on Long Island	80,000 00
For contingencies	20,000 00
	200,000 00

PRESERVATION OF PROVINCETOWN HARBOR.

This work was under charge of Lieutenant Colonel J. G. Foster, Brevet Major General United States Army, during the whole fiscal year.

The bulkhead and jetties of brush, referred to in my last annual report, have been completed during the fiscal year ending June 30, 1869. The contract for this work was awarded to Mr. Isaiah Gifford; the lowest bidder, Mr. Thompson, having declined to give the required bond for the faithful performance of the contract.

The work was pushed to a successful completion by the contractor, and the results have been very favorable; several of the jetties and a part of the bulkhead gathered sufficient sand to completely hide them from view. This construction has realized my expectations, as the sand commenced to gather at once in the jetties farthest to the eastward, and is steadily accumulating towards the westward, and will, in a very short time, present a firm obstruction to the encroachments of the ocean upon Beach Point.

As many of the inhabitants of Cape Cod expressed a fear, as intimated in my last annual report, that the encroachments of the sea upon the outer or sea-beach would result, during some great storm, in the formation of a breach through the sand ridge into East Harbor, it was determined, with the consent of the Chief of Engineers, to build a dike across the salt meadows and East Harbor Creek, at the narrowest part, opposite High Head, to arrest the flow of waters, should this event happen.

The contract for this work was awarded to Mr. Gideon Currier, the lowest bidder, and the work was completed in May, at an expense to the United States of $8,657 05.

The work has been well constructed, and will present a firm resistance to the flow of the waves should the Atlantic Ocean, at any time, effect a breach through the outer beach.

Observations for determining the tides and currents, and the nature and extent of the changes in Provincetown Harbor, were carried on, by direction of the Chief of Engineers, under the immediate supervision of Captain Geo. Burroughs, Brevet Major United States Army, whose report, with the accompanying maps, was forwarded to the Chief of Engineers April 16, 1869.

In order to repair and strengthen the plank bulkhead built by General Benham at Beach Point, advertisements were published on the 15th of June, 1869, inviting proposals for repairs to the same, and for the construction of brush jetties in front of it, for the purpose of strengthening it. These jetties are to be of the same nature as those constructed during the past fiscal year by Mr. Gifford, to the westward of the plank bulkhead, and which have answered the desired purpose so admirably.

Contracts will be made, and during the present working season these jetties and the repairs to the bulkhead will be completed.

Amount on hand and in treasury July 1, 1868	$36,751 26
Amount expended during the fiscal year ending June 30, 1869	30,126 87
Amount allotted to this harbor during the year	8,000 00
Amount on hand, in treasury and sub-treasury, July 1, 1869	14,524 39
Amount that will probably be expended during the fiscal year ending June 30, 1870	14,524 39
Amount required to be appropriated for the fiscal year ending June 30, 1871	25,000 00

It is difficult to determine the amount that will be required for the permanent completion of the works in this harbor, as the constructions are light, and the harbor is so exposed to violent gales and the heavy waves of the Atlantic that damage of a more or less serious nature may at any time be caused, which will require immediate repairs.

MERRIMACK RIVER.

Two surveys were made of this river in accordance with instructions received from the Chief of Engineers; the first survey was made under the immediate supervision of Captain G. L. Gillespie, brevet lieutenant colonel United States Army, and comprised the obstructions from the mouth of the river to Newburyport. The second survey comprised the obstructions between Haverhill and Lawrence, at the rapids near Bradley's farm. On this occasion I visited the principal points of obstruction myself. Detailed reports of these surveys were forwarded at the time of their completion.

As no appropriation is available for the removal of these obstructions, no work will be done during the present working season.

The amount required for the entire and permanent removal of these obstructions, as estimated for in the above mentioned report, is as follows:

For removal of obstructions at Upper and Lower Falls....	$50,500 00
For removal of Gangway Rock..........................	2,250 00
For removal of wreck of coal vessels sunk near the mouth of the river..	5,000 00
For removal of the boilers near the city wharves at Newburyport..	5,000 00
For contingencies, 10 per cent..........................	6,275 00
Amount required to be appropriated....................	69,025 00

I have the honor to be, general, very respectfully, your obedient servant,

J. G. FOSTER,
Bvt. Maj. Gen. U. S. A., Lieut. Col. of Engineers.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers, Washington, D. C.

S 1.

WASHINGTON, D. C., *March* 5, 1869.

GENERAL: I have the honor to submit my final report of the operation of blasting and removing Tower and Corwin Rocks in the narrows of the harbor of Boston, with seven sheets of drawings, illustrative of the details of the operation.

I do this with the hope that it may be published as one of the papers of the corps, provided it meets your wishes and receives the approval of the Secretary of war.

Very respectfully, your obedient servant,

J. G. FOSTER,
Bvt. Maj. Gen. U. S. A., Lieut. Col. Engineers.

Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

Removal of Tower and Corwin Rocks in the narrows of the entrance to Boston Harbor, Massachusetts, by drilling and blasting.

These rocks were situated (sheet 1) in the main ship channel between the Great Brewster Spit light and Fort Warren, nearly in a southwest direction from the light, the first being distant from it one hundred yards, and the latter two hundred yards.

The sailing course laid down on the charts passed directly between these rocks, and vessels had, therefore, only 150 feet space on each side in which to avoid collision with them, which rendered the navigation quite dangerous from heavy vessels.

This danger was increased by the risk of mistaking, in thick weather, the large navy yard chimney for the Bunker Hill monument, upon which the true course passing through Nix's Mate was directed. The course through Nix's Mate and the navy yard chimney led directly over Corwin Rock. Being nearly in the same direction, one course might very readily be mistaken for the other in thick weather at the distance of these rocks.

The depth upon Tower Rock at mean low water was eighteen and a half feet.

It was fifty feet in length and twenty-six feet in breadth, and contained above the level of twenty-three feet below mean low water sixty-three cubic yards. Corwin Rock had only sixteen feet of water upon it at mean low water, was one hundred and ten feet in length by eighty feet in breadth, and contained above the twenty-three feet level six hundred cubic yards.

The two rocks were ridges of the same general ledge which extends beneath the channel, running in a northwest and southwest direction.

An examination of Corwin Rock by divers disclosed the ragged and ridged character of its surface, and the presence of a considerable quantity of sheet lead and copper in its crevices; also bolts, chains, pieces of planks from vessel's bottoms, pieces of a keel, an anchor, &c. The sheet lead was of a very old manufacture, and both it and the copper retained the crumpled form given them by the sharp edges of the rock when they were stripped off. Everything indicated that a great number of vessels must have struck upon this rock in times past, of which number the old frigate Constitution was one. The last one known to have struck it was the China, of the Cunard line.

CHARACTER OF THE ROCK.

The rock was an argillaceous slate, of hard compact texture and irregular stratification, some portions being much twisted and bent, forming every variety of conchoidal surface. (Fig. 10, sheet 4.)

The weight of a cubic foot of the rock varied from 155 to 180 pounds, giving a mean of 165 pounds, the same as granite.

The rock operated very disadvantageously in blasting. It did not "seam" well. The rifts rarely extended beyond the immediate effect of the charge. The craters and size of the fragments thrown out were small; and generally the effect of blasts was much less than in granite.

The presence in the rock of crystals of sulphuret of iron, or iron pyrites, retarded much the operation of drilling, as they were so hard as to break or cut a piece out of the cutting edge of the drill whenever it struck them.

The circumstances, therefore, were regarded as less favorable for blasting and removing than in the majority of cases of submarine rocks.

ESTIMATED COST AND CONTRACT.

The cost of removal of these rocks to the depth of twenty-three feet at mean low water, as estimated by the board of harbor commissioners of the State of Massachusetts, was $20,000, and this amount was assigned to this particular work by the Engineer Department from the general appropriation, approved March 2, 1867, for improvement of Boston Harbor.

Proposals were advertised for, in June, 1867, but no one could be found to undertake the work by contract for the sum available, the only bid received being for $44,000. It was, therefore, decided to execute it by days' work. A contract was accordingly made with Mr. George W. Townsend, submarine diver, of Boston, by which, for the sum of $90 per working day, he was to furnish a working vessel of seventy tons, fitted for the purpose with steam engine, boiler, boom derrick, and capstan to work by steam; the services of a captain and crew of six men, two submarine divers, with their armor, air pump and hose complete, a patent submarine drilling machine, mooring lines, buoys and materials of every description, including powder, cartridges, and fuses.

This contract was amended in October, 1867, by increasing the amount to be paid per diem to $100 for every day's work of nine hours during the winter season, in addition to which, powder, cartridges, and fuses were supplied by the government. In March, 1868, the amount per diem was again reduced to $85 per working day, at which price the work was prosecuted to completion, the contractor furnishing all the labor and materials required, with the exception of powder, cartridges, and fuses, which, being variable quantities, were paid for separately.

The amount available becoming exhausted, further sums, amounting to $16,432 32 in all, were assigned to the work by the Chief Engineer, making the total amount assigned $36,423 32.

COMMENCEMENT OF THE WORK—TOWER ROCK.

Tower Rock, being the smaller of the two, was selected as the one to be first removed, its horizontal dimensions being only 50 by 26 feet; it was estimated that one large central charge, surrounded by five or six others, all in large and deep drill holes, would be able to rend the rock into pieces.

The working vessel, the sloop Hamilton, of seventy tons, was moored over this rock on the 30th of July, 1867, and the new submarine drilling machine, invented by Mr. George W. Townsend, the contractor, expressly for this work, was placed in position and tried. Several imperfections were found at the first trial, which prevented its efficient working. While these were being remedied a trial was made of surface blasts, placed in and around the rock in the positions most favorable for their action. These proved to be entirely without effect; no seams or breaks were made by them in the smooth surface of the rock.

The submarine drilling machine being soon perfected, was put in operation, and successfully worked.

The central and surrounding holes were drilled to depths varying from two to six feet, each hole being three and a half inches in diameter.

These were well charged with blasting powder, tamped with sand, and fired. In some holes the charges produced no visible effect, the tamping being blown out like the charge from a cannon. In others a crater was formed, but with a radius only about one-half the line of

least resistance. The holes that were intact were then deepened, and new ones drilled. These were charged with Dupont's sporting powder. The result was much better, but not what was desired. The presence of the body of water, from twenty-three to thirty-three feet in depth, seemed to diminish largely the ordinary explosive effect of gunpowder upon rock, as seen in blasts in the open air.

Trial was then made of the patent safety blasting powder, manufactured by the Oriental Powder Company of Boston, the proportions having been so modified as to increase its strength for our special use. This produced the desired effect. The rock was rent in pieces; and by drilling additional holes and continuing the use of large charges of this powder, the rock was finally reduced to the required depth.

To smooth off its upper surface, and break down the sharp projecting points, large surface charges of sporting powder were employed. These accomplished the result to a limited extent, but not completely. A large fifteen-inch shell was then placed in a crevice near the centre of the rock and fired. Its explosion swept the rock completely, breaking down and levelling the projecting points.

The work upon this rock was finished on the 29th of September, 1867, eight weeks after its commencement. In that time eighty tons of stone had been blasted out, hoisted up, and deposited on shore, attaining the required depth of twenty-three feet at mean low water. About seventy tons of small fragments were suffered to remain on the bottom around the rock where they had been thrown by the blasts, and where they could do no harm.

The cost per ton of the quantity hoisted up and deposited on shore was $64 93, no account being taken of the equal quantity blown in small fragments into deep water.

PROGRESS OF THE WORK—CORWIN ROCK.

Tower Rock being entirely removed to the required depth, the moorings of the working vessel were at once removed to Corwin Rock, and work commenced upon it on the 1st of October, 1867.

This rock was found to be much more difficult to blast, on account of its extremely tortuous lamination, its great toughness, and the presence of a greater number of iron pyrites.

Surface blasts were also tried upon this rock at the outset, in hopes that, by being placed in the most favorable positions between the sharp ridges of the rock, they might break them down.

These, however, as upon Tower Rock, entirely failed of any noticeable effect, even when they contained four and five hundred pounds of the best sporting powder. The drilling machine was therefore called into requisition, as before, and used continuously to the completion of the work.

On account of the extent of this rock a different plan of operations for its removal was adopted. One side of the rock most favorable for blasting was selected, and a row of holes drilled parallel to the edge and at a distance from it equal to the depth of the holes, which was taken to extend one foot below the required level—twenty-three feet at mean low water.

After blasting out these holes a new line of holes was drilled parallel to the former line or to the "face" left by the blasts, and these also blasted out. Then a third line; and so on, progressing regularly across the rock, continually blasting it off in parallel blocks, extending downward a little below the depth required.

The advantages of this mode of operating were, that it enabled the blasts to act laterally, in which direction they were the most powerful; and

the rock was left, after each series of blasts, with a nearly vertical side or "face," in which the presence of seams could be more readily detected and the character of the strata observed, so that the most favorable positions for the next blasts, to produce the greater effect, could be selected.

Sometimes the craters following the strata ran under or left an overhanging "face," in which case a large charge placed under its projecting edge, (see Fig. 10, sheet 5,) usually had the effect to throw off the overhanging portion, and sometimes to dislodge large masses.

After the rock had been in this way blasted entirely across and to the general depth required, a careful survey was made; the soundings being taken in lines from five to ten feet apart and at right angles to each other, and the lower end of the sounding pole being placed by the diver alternately upon the highest and lowest points.

This survey showed that although more than the required depth had been generally attained, yet many points projected above this level, distances varying from two to fourteen inches. To remove these, large surface charges were again tried, but with the same ineffective result. The only effect was to pile up the sand and small fragments of stone in irregular winrows upon the surface of the rock. Small holes had, therefore, to be drilled at each of these points to blast them off. This occupied much more time than could reasonably have been expected. So that it was not until two months' labor had been expended that all the points were finally reduced to the required level.

It is now apparent that it would have been an economy of time and money if, from the commencement, the drill-holes had been sunk to a general level two or three feet below the required level, instead of one foot below, as was estimated to be sufficient, at starting. More stone would have been taken out, it is true, and also the upper surface of the rock would have been left irregular and angular, instead of comparatively smooth as now, but the time and expense would have been less.

The work on Corwin Rock was continued during the few days of winter of 1867–'8, resumed fully in the following spring, and completed on the 15th day of December, 1868, the total working time occupied in its removal being two hundred and ninety and one-half days.

During this time 1,192 tons of stone, by weight, were blasted out, hoisted up, and deposited on shore. About 164 tons of small fragments were left on the bottom around the rock, where they could do no harm.

The total cost of removal was $31,228 61; making an average cost of $26 20 per ton of 2,000 pounds, or $58 36 per cubic yard for the quantity actually removed and deposited on shore. Taking 600 cubic yards, the cubical contents above the 23-feet level, calculated before the work was begun, the cost per cubic yard of the work, as estimated, becomes $52 05. The difference between the actual and estimated cost per cubic yard is due to the greater quantity actually removed to obtain the required level at all points, making the mean actual depth nearly one foot below that level; and also to the quantity of small fragments blown into deep water, and not included in the amount of stone hoisted up, weighed, and deposited on shore.

DESCRIPTION OF THE SUBMARINE DRILLING MACHINE USED AND ITS MODE OF OPERATION.

This machine (sheet 3) consists generally of a drill, a drill-stand or guide, a clutch or hoister, and an adjustable connection with the motive power situated on the deck of the working vessel.

The drill (sheet 4) is a churn drill, about 16 feet in length, one and a quarter inch in diameter, and weighing about 125 pounds. It cuts by the force due its weight, which may be made greater or less as the rock to be drilled is softer or harder.

The drill-head (sheet 4) or cutter is about 14 inches in length, and is attached to the lower end of the drill-shaft by a socket and pin. The *cutting edge* is made similar to the form of the letter S, as this is found to stand better and work truer than any other form. They may be made to cut any sized hole from two to six inches.

The cutters used on Tower and Corwin Rocks drilled a hole three and one-half inches in diameter.

The drill-stand (sheets 3 and 4) consists of two parallel plates connected by uprights, to serve as guides to the drill-shaft; the lower plate being supported by three legs made adjustable in length to fit the uneven surface of rocks. It is made of iron, and heavy enough to resist an ordinary current. The one in use on Tower and Corwin Rocks weighed 850 pounds, and maintained its stability perfectly against a four-knot current. To resist stronger currents its weight must be increased, and also three guys attached to the upper plate and to iron pins driven into holes drilled in the rock by the diver, with a hand drill, may be used if necessary.

The clutch or hoister (sheet 4, Fig. 9) is a bar of iron, with an oblique slot through it, through which passes the drill-shaft.

When the clutch is raised the sharp beveled edges of this slot grip the drill shaft and raise it. One end of the clutch is forked to run upon a spiral guide, so as to turn the drill as it is raised. The other end is weighted so as to bring the clutch rapidly back to its first position, after its grip upon the drill-shaft has become disengaged by a trip-pin on the spiral guide, against which the fork of the clutch strikes in its ascent.

The spiral guide, which regulates the turn of the drill, is made adjustable in inclination, so that greater or less turn may be given for any fixed elevation or hoist. The trip-pin is also made adjustable in position upon the spiral guide, so as to regulate the hoist or fall of the drill to suit the degree of hardness of the rock. It is usual to give as great fall as the cutting edge of the drill will stand without breaking.

Attached to the clutch is a chain, which passes through a hole in the upper plate, and is attached at its upper end to a ballasted block, (sheet No. 2.) Through this block a line is rove, one end of which is attached to the crank-pin of a steam-engine situated on the deck of the working vessel, and the other end to a cleat upon the rail of the vessel.

TO OPERATE THE DRILL.

The working vessel having been moored over the rock by means of moving lines attached to buoys placed about one hundred and fifty feet from each quarter of the vessel, the diver arrayed in his submarine armor descends and selects the exact position for the blast, and then signals, by a certain number of pulls upon his signal line, to have the drill and stand lowered to him. This being quickly done by means of the steam derrick, he guides the drill-stand to its place, and finally fixes it in position by means of its adjustable legs. He then signals to haul up and make taut the drill lines attached to the motive-power on deck; and this being done, he signals to commence drilling.

The crank plate of the engine being thrown into gear, the engine being in motion, the end of the drill line attached to the crank-pin is raised, which raises the ballasted block, the drill chain, and the clutch; which

latter grips and raises the drill, turning as it rises, until the forked end of the clutch strikes against the trip-pin, when the drill chain still hoisting, the grip of the clutch is disengaged and the drill falls straight, cutting the rock by the force due to gravity. The crank plate continuing its revolution, the drill line and chain are lowered, permitting the clutch to descend to its first position ready to grip and raise the drill again.

The revolutions continuing, the drill is raised and let fall, making a cut at each revolution of the crank plate; and in this manner the drilling proceeds. Usually the drill makes from sixty to eighty blows per minute.

As soon as the diver sees the drill in perfect operation, he either busies himself with any other work that he may have to perform upon the bottom, or he comes to the surface of the water, and supporting himself upon the ladder attached to the side of the vessel for his use waits for some necessity of his diving again.

Sometimes the drill works uninterruptedly till the hole is drilled to the depth desired. At other times its working requires the constant attendance of the diver, either in replacing drill-heads broken by contact with hard crystals, or in regulating the "turn" or "hoist" of the drill, or in clearing the holes of cuttings, or "spooning out," as it is termed, or rectifying the direction of the drill by adjusting the legs or guys. To afford an indication above water of the motion of the drill below, and thus to obviate the necessity of the diver's going down for this purpose, an iron rod is fitted into a square socket on the upper end of the drill-shaft, and to the upper end of this rod a wooden pole, extending above water, is attached. (Fig. 12, sheet 4.) This pole being held by an attendant standing upon a movable staging, (sheet 2,) rigged out from the side of the vessel, indicates clearly to him the motion of the drill, and also enables him, with his hand, to prevent the drill falling repeatedly into the same cut, or "bouncing back," as it is termed. In rough weather this staging and index pole cannot be used. At such times the motion of the drill line is the only indication, above water, of the working of the drill; frequent descents of the diver are then necessary. The tendency of the drill to "bounce back" is then prevented by a ratchet and pawl (Fig. 2, sheet 4) placed on the upper guide plate, and operated by a vertical groove in the drill-shaft and a pin on the ratchet.

It was found that the drill could be worked in a rapid current as well as in slack water. This will enable the operation of drilling and blasting to be conducted in an extremely rapid tidal current, by a proper division of time and labor, so that the principal work of the divers in inserting charges for blasting, slinging stone, &c., may be done near the periods of slack water, while the drilling may be advantageously continued during the period of rapid flow.

Upon Corwin Rock the current had a velocity of four miles an hour, which did not interfere in the least with the work of the divers at any stage of the tide.

In a rapid current the stoppage of the drill for the purpose of "spooning out" the hole becomes unnecessary, as the motion of the drill works up the powdered cuttings to the mouth of the hole, whence they are sucked out and carried off by the current in a dark stream like the smoke from the stack of a locomotive.

In a sluggish current or during slack water the hose of the air-pump was sometimes introduced, and air forced into the hole, creating a current of water extending to the bottom, which, by this means, was cleared of cuttings more thoroughly than by the most careful "spooning out." To attach this arrangement permanently to the drill, it is proposed to have a small hole along the axis of the drill-shaft, with outlets on each

face of the cutter, and a hose attached by a swivel to the upper end of the shaft, through which air or water is to be forced to the bottom of the hole, by which means the drill may be kept constantly clear.

CHARGING THE HOLE, FIRING, ETC.

As soon as the hole is drilled to the required depth, the drill is stopped: the drill line is detached from the crank-pin and unroved from the ballasted block; the diver then descends, fastens the derrick chain, which is lowered to him for the purpose, to the drill stand, and then signals to hoist away; upon which the whole machine is quickly hoisted on deck. After an examination of the hole and clearing away any cuttings remaining in the bottom, the diver comes to the surface, and taking in his hand the charge contained in a water-tight cartridge, (sheet No. 5,) usually of india-rubber, carefully prepared with its fulminating exploders inside, its mouth hermetically closed, and insulated wires extending to, but not yet connected with the electric battery on deck, descends and inserts it into the drill hole, carefully pressing it to the bottom with a rod.

The tamping, (Figs. 1 and 2, sheet 4,) if any is used, is then inserted above the cartridge and the diver comes up.

The working vessel is then quickly hauled by the mooring lines to a safe distance, the capstans worked by the steam-engine being used for the purpose; the wires are then attached to the battery, a few turns are given to its crank to generate electricity, the operator asks "all ready?" and being answered "all ready" by the diver, pulls the connection knob, when a shock, followed instantly by a second shock, and the upheaval of the water, announces the explosion of the charge. The working vessel is then hauled back to her position by steam as before, and as soon as the water becomes sufficiently cleared of the dark muddy matter with which it is filled by the blast, to enable the diver to see in it, he descends and examines the result. If the blast has been effective and thrown out a crater from the rock, he signals for the stone chains to be lowered to him, which being done, he proceeds to sling the large pieces of broken rock one after the other, as they are hoisted up by steam and deposited on deck. All the pieces large enough to sling being thus removed, he signals for the tub and shovel, and upon their being lowered to him, proceeds to shovel into the tub the small fragments, and to have them hoisted up and piled on deck until the surface of the rock is sufficiently cleared to place the drill for a new hole and another blast. This operation is repeated and the work thus progresses steadily.

After some experience, such facility can be attained in drilling and blasting as to enable the work to be continued in a rough sea, and during all stages of the tide. To accomplish this, the slot in the clutch must be made of such an oblique form as to permit the clutch to run up the drill shaft, after tripping a sufficient distance to accommodate its motion to the upward heave of the vessel in a swell of the sea.

The particular adjustable connection between the drill and the motive power must also be so arranged as to afford the means for compensating for the rise and fall of the tide, by simply letting out or taking in the line attached to the cleat on the rail of the vessel, (sheet 2.) In addition, this arrangement must also enable the vessel when threatened by a collision, or a sudden storm, by casting off this line to detach itself entirely from the drill and haul out of danger. After the danger is passed, the working vessel can readily haul back again, pick up the drill line, and at once resume work. This last facility was found to be of much value,

since, from the position of the rocks in the middle and narrowest part of the channel, the collisions with passing vessels were frequent, especially during the prevalence of light winds and strong currents. The drill was repeatedly knocked from its position on the rock by the keel of passing vessels. Its simple construction, however, enabled a blacksmith to repair all damages in a few hours. To reduce the chances of collision with passing vessels, the lower ends of the supports of the upper plate were made hinged, (Figs. 6 and 7, sheet 4,) so that the whole upper part of the frame could be turned over, thus reducing its height to about four feet. This was a great advantage whenever it became necessary to leave the frame standing by itself upon the rock, as was usually the case at night, when the working vessel sought its anchorage under the lee of Lovell's Island.

During the day a red flag was always displayed in a conspicuous position on board the working vessel, to notify masters of vessels of the character of the operations in which she was engaged, as described in a published notice, and to warn them to avoid a collision.

POWDER USED.

The powder used in the drill holes at first, as previously stated, was common blasting powder. This proving too weak to rend the rock, Dupont's best sporting powder was tried, in charges from six to twenty pounds, with better but not satisfactory results. It at once became evident that a stronger blasting compound must be obtained. Trial was then made of the patent safety blasting powder, manufactured by the Oriental Powder Company of Boston. Its composition as manufactured for general use is—

	Parts.
Chlorate of potash	50
Kutch or gambia	50
	100

This gave results nearly twice as great as the sporting powder. A charge of it placed in a drill hole from three to eight feet deep could almost invariably rend the rock, and throw out a crater more or less extended.

Trial was also made of a powder made from the proportions furnished by Dr. Charles T. Jackson, State assayer of Massachusetts, as follows:

Chlorate of potassa	490
Yellow prussiate of potash	280
Powdered loaf sugar	230
	1,000

This gave equal results to the chloride powder above, but as there was no manufacturer of this powder for general use, the other was employed, and by special agreement made much stronger than usual, to obtain the greatest possible blasting effect. The proportions used were:

	Parts.
Chlorate of potash	80
Gambia	20
	100

The price paid for this was $15 per box of twenty pounds. An effort was made to obtain nitro-glycerine, at first, but unsuccessfully, as none could at that time be procured nearer than New York, and even then with considerable difficulty attending its purchase and transportation. Subsequently the chloride powder in its increased strength proving entirely satisfactory in its results, it was no longer necessary for the progress of the work to get a stronger explosive. It did not therefore seem proper, with a just regard for the safety of the divers, to add to the ordinary risks of their avocation the additional danger usually attending the use of this highly explosive compound. As it was, no accident from the use of powder occurred during the whole work, although large quantities were at times kept on board the working vessel. As a general thing, however, the powder was kept stored for safety in a small house on shore, near by, where the cartridges were filled, and thence brought off in a boat when needed.

For blasting in seams or under projecting faces, when large charges were required, the best sporting powder was used, as it was found to be more effective under those circumstances than the patent safety blasting powder. It was only in the drill holes, or when confined, that the latter exhibited its superior strength.

It was found that surface blasting was generally without effect, even when from three hundred to five hundred pounds of the best sporting powder were used in a single charge. It was only when charge could be inserted into a seam made by previous blasts, or placed under a projection, that it produced any effect. The cost and quantity of powder used are given in the following table:

50 pounds white powder, at $2	$100 00
6 cases patent powder, at $13 50	81 00
6 cases patent powder, at $15 50	93 00
57 cases patent powder, at $15	855 00
548 kegs sporting and gun powder, at $6 50	3,562 00
	4,691 00

CARTRIDGES.

Of these numerous varieties were tried in the search for one that combined all the requisites of impermeability to water, lightness, incompressibility and cheapness. Lightness or buoyancy of material was required in order that the fragments of the cartridges, after an ineffective blast, might float out of the hole and not remain in to choke it and prevent the introduction of a new charge. Incompressibility was requisite to prevent the powder becoming caked from the pressure of the heavy column of water, in which state the ignition from the fuses or exploders was slow and incomplete. Cheapness was a desideratum, but not a controlling one. The absolute requisite was that the cartridges should be water-tight. Trial was first made of tin canisters. These were water-tight, incompressible when braced inside, and cheap; but when used in drill holes, (Fig. 5, sheet 4,) they had the defect described above, of the exploded tin canisters choking the hole and preventing a new charge being pushed to the bottom. This caused their abandonment as cartridges for drill. They were always used, however, to contain the charges for large blasts in crevices, large seams, or under projecting faces. They were of the usual form seen in Figs. 9 and 11, sheet 5, and were mostly braced crosswise on the inside to prevent being collapsed by the

pressure of the water. For seams, the canisters were made flat and thin, as seen in Fig. 12, sheet 5, and were also braced in the interior.

Trial was next made of India-rubber cartridges, (Figs. 3 and 4, sheet 5,) of a cylindrical form for drill holes. These answered very well, better upon the whole than any other kind. They possessed the indispensable requisite of being perfectly water-tight, and of leaving after the blast no debris to fill the bottom of the hole. They also being elastic, easily yielded to any irregularities of the hole, so as to be readily pushed to the bottom. The mouth was easily made water-tight by being tightly wrapped around the electric wire with twine, and then covered with a water-tight compound. They had, however, the defect of being compressible, so that at the depth of thirty feet below the surface the powder in them became caked almost as hard as a stone. The cost was also greater than for any other kind, being from thirty-seven and one-half to seventy-five cents each.

The India-rubber cartridges to contain charges to be placed in seams in the rock, were made long, wide and flat, and were stitched like a life preserver, in vertical parallel rows, not extending quite to the bottom or top. (Figs. 13 and 14, sheet 5.) They answered well, as they readily adapted themselves to the irregular forms and cavities of seams. The principal difficulty was in filling them with powder, on account of the small tubes formed by the stitching.

Wooden cylinders made of successive wrappings of thin wood cuttings such as are used in covering walls instead of paper, (see Figs. 7 and 8, sheet 5,) were next tried. In some the wooden sheets were wrapped with the fibers longitudinal, in others transverse, in others diagonal.

The bottoms and tops were also of wood, turned to fit tightly, and covered with water-tight composition. These cylinders were incompressible, also buoyant, so that the fragments, after a blast, floated out of the hole. The cost was also small, being about twenty cents each. But they were not water-tight. The pressure of from twenty-three to thirty-five feet of water forced so much moisture through the pores as always to dampen and frequently to thoroughly wet the powder so as it would not explode. This was the case, although to a less extent, even when the cylinders were wrapped with paper steeped in coal tar, paraffiine, and other water-proof substances.

Thick paper cylinders (Fig. 6, sheet 5,) covered with water-tight substances, were next tried. These were buoyant, cheap, and nearly incompressible, but in a majority of cases they proved not to be water-tight. The pressure of water caused the coatings to crack.

Iron cylinders cast very thin were proposed, but not tried, as their fragments would be likely to jam in the hole after a false blast, and preventing getting a new charge down to the bottom. They might also jam in an angular hole. A similar difficulty was experienced in the use of some gun-metal cylinders, cast like the cup of the Minie ball, that were tried over the charges for tamping.

Glass cylinders or long bottles were also proposed, but not tried, as the divers objected to their use on account of the broken glass which would mix with the fragments of stone, being likely to cut their hands in handling the stone, and also to cut through their submarine dress while working upon their knees, in which position most of the work about the drill, and in shoveling up the small pieces of stone, has to be done. A single small cut in a diver's dress would let in water enough to immediately fill his armor. We were therefore forced to continue the use of the India-rubber cartridge notwithstanding its cost and compressibility. The latter defect was obviated to a certain extent by

the diver constantly manipulating the filled cartridge with his hands from the time he went under water until he placed it in the hole ready for blasting, after which he came directly up, and the charge was fired without loss of time. In addition, several exploders were used in each of the larger charges, so as to give several points of ignition to insure complete combustion.

MEANS FOR EXPLODING THE CHARGES.

Within the charge was placed one or more exploders, or fuses, containing fulminating powder, placed between and around the slightly separated ends of two fine copper wires, (Fig. 1, sheet 6.) The spark produced by the passage of the electric current between these two wire ends explodes the fulminate, and thus ignites the whole charge. The wires in these exploders are connected with two other wires in an insulating coating of gutta percha, which extend above water and to the portable electric battery on the deck of the working vessel. Sometimes these wires were in separate insulating coverings, as in Fig. 6, sheet 6, and at others both in the same covering, as in Fig. 5.

Great pains were always taken to make the mouth of the cartridges where these connecting wires entered the charge hermetically tight, by means of a tight-fitting cork or wrapping of twine, over which a thick coating of a water-tight compound of melted India-rubber, lard and rosin, was carefully pressed and molded. All this was done on the deck of the vessel, before the charge was taken below by the diver.

The conducting wires may be either iron, steel or copper, the latter being preferred for its superior conducting power. Two were usually employed as stated above, but at one time, when a very large charge was to be fired, it became necessary to use the whole length of the wire, in order to enable the sloop to lie at a safe distance.

In this case a short portion of the second wire from the cartridge was left to project into the water, while a similar portion of wire connected with one pole of the electric battery was suffered to hang over the side of the vessel into the water. When the poles of the battery were connected, as usual, to fire the charge, its explosion took place instantly, the return current passing through the water from the end of wire projecting from the cartridge to the end hanging overboard precisely as though connected by wires.

The exploders for small charges were single, (Figs. 1 and 3, sheet 6;) for larger ones they were double or treble, and for very large charges a large number, as many as fifty in some cases, were attached together, forming a string, (Figs. 2 and 4, sheet 6.) For such a string the exploders were made of a more sensitive fulminate, expressly prepared for the purpose by their manufacturers, Messrs. Moore & Smith, No. 62 Sudbury street, Boston, by whom the conducting wires and the friction battery were also made.

The friction battery is of a simple construction, as seen in Figs. 1 and 7, sheet 7. It is only about one foot square by two inches in thickness, and is portable, light, and convenient for use. Although so small, it contains all the necessary parts of such a battery, a friction wheel, Leyden jar, and connecting poles, all contained in an insulated covering.

Its simplicity, lightness, and compactness, recommend it for service in the field to fire temporary mines, fougasses, &c., or on the coast to fire the torpedoes used against shipping, or in forts to fire the heavy guns.

To fire a charge with it, the connecting wires from the exploders in

the charge are first attached to the two knobs of the instrument; a few turns are then given to the handle to generate the electricity; then everything being "ready," the order to "fire" is given, when the knob to connect the poles is pulled by the operator, and the explosion takes place instantly.

No exploder missed fire during the whole course of the work upon Tower and Corwin Rocks.

The friction battery requires to be taken in pieces about once in a month to clean the friction plate and its compartment of the loose powder and dust, and to renew the "mosiac gold," or sulphuret of tin, upon the spring friction rubbers. It should, when not in use, be kept in a warm, dry place.

TAMPING.

At first common sharp sand mixed with fine gravel was used, but it was found that, at the depth of the charges, twenty-three feet at low and thirty-three feet at high water, the sand became so buoyant as to be deprived of the compactness necessary, in tamping, to produce effect.

Metal tamping was then tried. Of these the Lavis form (Fig. 1, sheet 5) was always effective, but had the disadvantage of being introduced with difficulty.

A gun-metal cylinder, (Fig. 2, sheet 5,) with one end closed, except a small orifice for the electric wires, was then tried with success. The upper part of the cartridge fitted into the cup of this tamper, and both were lowered into the hole together. In firing, the cup expanded like that of the Minie ball, causing the outside of the cylinder to adhere by friction to the sides of the drill-hole.

Generally the best results in blasting were obtained by first exploding in the drill-holes successive small charges, without tamping, until seams were started in various directions, and then using a heavy charge of patent powder, with a good tamping like the gun-metal cylinder, so as to dislodge, if not to hoist out, all the masses of rock that had become disconnected by the seams.

S 2.

BOSTON, MASS., *April* 16, 1869.

GENERAL: I have the honor to inclose herewith report of Major Burroughs, of operations at Provincetown. I also inclose notes of current and tidal observations at that station and send map of Cape Cod Harbor, upon which the results are delineated.

Very respectfully, your obedient servant,

J. G. FOSTER,
Bvt. Maj. Gen. U. S. A., Lieut. Col. Engineers.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers,
Washington, D. C.

UNITED STATES ENGINEER OFFICE,
Provincetown, Mass., April 12, 1869.

GENERAL: I have the honor to submit the following report in reference to the current observations in this harbor, lately made by your

orders, with the party under my charge, to accompany the map which has been prepared.

April 6, 1868, the Chief of Engineers directed General Benham to make certain observations, investigations, &c., in view of the preservation of the harbor at this point and of a determination of the causes of damage to it. June 9, the Chief of Engineers transferred to yourself the charge of the work and temporarily relieved me from duty with General Benham, to conduct, under your direction, "surveys and works for preservation of Provincetown Harbor." The transfer was effected by June 24. From that date until July 13, the time was occupied in preliminary examinations, procuring boat material, (floats, &c.,) office party, &c., &c. Drawings of the projected dike, at the "Wading Place," in East Harbor, and of the proposed brush bulkhead on Beach Point, were also prepared, contracts advertised for, &c., during that interval. July 13 I took station at this place and commenced observations on the currents, those near East Harbor being taken first, on account of the progress in the construction of the State dike closing the entrance into this inlet. At that time the rows of round piles had not been driven completely across the entrance. This work gradually continued until, on November 4, the tide was entirely shut off. After that date, I took a few observations there, as shown on the map.

The apparatus for sub-floats consisted of hollow India-rubber balls, (ordinary "foot balls,") about one foot in diameter, pierced on the side with four one-inch holes, to allow them to fill with water. They were supported inside by stiff wire frames, weighted (according to depth to which submerged) with leaden washers, attached to the under side to a small loop, and connected by a fine copper wire with a surface float. The balls were submerged to any required depth, the amount of washers necessary being readily determined in each case by the strain upon the wire. The copper wire was soon abandoned, as it was found to get into loops or "kinks" and to snap off. We lost one sub-float in that way, and barely saved another. We then used a very fine cotton line, such as is used in fishing for mackerel. This did well, there being no visible difference between the practical utility of the two. The surface float was composed of two cross pieces of wood, very thin and light, eighteen inches each in length, placed at right angles to each other, and supported at each extremity by flat India-rubber floats, each six inches in horizontal diameter, the line, connecting with the sub-float, being fastened under the junction of the crossed pieces. At the same point a light staff was inserted, from two to three feet high, carrying a light flag. At first streamers were tried, six inches at the head and nine inches fly, but, finding it difficult to see them at long distances from the shore, we were obliged to increase their size and change their shape, using rectangular flags, twelve inches at the head and eighteen inches fly. To keep them "out" we had very light strips of rattan rigged as a "sprit" and as a "boom" in each one. These flags seemed to take no more wind than the smaller ones. After trying different colors for flags, deep red and clear white were found to be best, the large red being visible perhaps a mile from the shore, and the large white at a somewhat greater distance, but both with some difficulty. For observations near the shore we made use of fixed points as posts, one thousand feet apart, placed on ordinary high-water line, ends of bridge, vertex of angle in same, &c. The angles were taken by two observers at adjacent stations, each one with a sextant, bringing together the other and the float, the time of each two angles being noted, of course, taken simultaneously at the preconcerted signals. The stations known, the inter-

section of the two angles' sides, not common, determine the position of the float at the recorded time. The observation, repeated soon after on the same float, from another position, the notes gave difference of time between the two, and the map the distance, as well as the path.

From time and distance velocity was obtained.

By this system of observations, under favorable circumstances, we could obtain a long path of the same float, with the change during its duration.

For observations in deeper water, on account of the distance, we were obliged to anchor a small sloop at the desired station, determine its position by two angles, between three fixed points on shore, (three point problem,) set off a float, determine its direction by an angle with some fixed point, &c., and its length of path by a line fastened at one end to the vessel, the other being attached to a skiff and kept abreast of the float. The length of the line was generally two hundred and fifty feet, necessarily short.

The copy of the notes, attached hereto, furnish the necessary data for both methods of observation. There are also a few notes on the map, on which, too, the different kinds of observations will be easily distinguished. I append a schedule of the tide observations, taken from the tide-gauge books, giving time of high or low water, stand, rise or fall in feet, &c., as observed.

Changes in the shore and other lines as given by the different maps, from which ours was taken, the comparison and union of them as given on ours, different degrees of shrinkage, &c., may have produced discrepancies; but it is hoped that the probability of error on ours has been reduced to the lowest point. The mean of differences has been taken as much as possible. This is especially the case on Beach Point.

In taking our observations, the limited time and other causes of difficulty given below, added to the evidently close approach to equality of sub and surface currents, (soundings generally shallow,) induced me to confine myself almost entirely to sub-currents. I, too, on account of growing sea-weed, bars, changes of tide, and consequently sounding, &c., was obliged to keep the sub-float well up from the bottom. It was my desire to furnish as complete a set of observations as possible. I should have liked to have extended them through a full set of tides, or at least to have given them at a more uniform stage of tide. I have tried to scatter them over as much of the harbor as I could, to show, even though at irregular stages, some indication of currents. I was hampered by the amount of space to be covered, the lateness of the season, the necessity of educating not only my party (observers, &c.) but myself, and above all, by the frequent, and as I am told, the extremely unusual amount of foggy and windy weather greatly impeding my progress. I took advantage of all the opportunities afforded, and have furnished as much as I think I could, with the drawbacks against which I labored.

This harbor is seldom free from wind for any length of time, even in one day. This very often rendered it impossible (on account of rough seas, &c.) to operate with the floats, more so last summer; (as said before) than it would probably have been in previous summers. Our floats were, I think, but little liable to the influence of a light wind, but perhaps too much so for perfect accuracy. I could not allow in any way for its effect, either in getting or while plotting the paths of floats. Here it seems to be nearly the powerful element. Vessels at anchor ride not with the tide, but invariably with the wind, light as it may be. The currents (there being no confined channel) work in all directions, and apparently, in general, but lightly, unless backed by the wind. The

spaces between jetties on bulkheads are fitted with sand mainly in certain favorable winds.

The various divisions, reflections, &c., of the general tide wave, in the "hook" of Cape Cod, and finally in Provincetown Harbor itself, shore-eddies and bars in the harbor, must account for the great irregularity in the direction of the paths of floats, as given on the map. In some cases the wind, too, must be considered, perhaps more or less for all, except those taken during a calm.

It is stated in "Navy Scientific Papers, No. 2, Tides and Tidal Phenomena," 1868, by Assistant Henry Mitchell, United States Coast Survey, that sand (about such as is here) is moved by water, having a velocity per second of 0.53 foot. Velocities on the map are in feet per second. The damage to the harbor by filling, from all information that I have, seems to have largely increased, as trees were cut down on the sand hills, for fire-wood, &c. There are now on the hills, north to northeast of the (former) outlet of East Harbor, trunks of trees which undoubtedly grew there. The sand of these hills, not being held by the shrubbery, of course would easily be blown about. In 1854, this kind of destruction was stopped by law; that it was in practice is not so certain. At the place, toward the head of East harbor, called "the Cove," (see map,) the bank, although grown over with beach-grass, is rapidly washing away on the outside, (see profiles, &c., already furnished.) Latterly the beach outside, at the same place, has received a deposit of sand, raising its level. This is probably only temporary.

The dike at "High Head" or the "Wading Place" will, it is trusted, protect from a break Beach Point and the State dike, should the sea wash through at the "Cove," or any similar weak place, a result that seems not improbable from present tendencies. As a means of stopping the wash of sand into the harbor proper from East Harbor, the State dike is effective and doubtless necessary; but should a place like the Cove give way, Beach Point would probably receive the first and greatest force of the inflowing sea—the latter spread out, it is true, but still formidable.

Now that East Harbor is closed in, the currents in that vicinity of course changed, &c., in order to be able to notice the effect on the flats in that part of the harbor, marked stakes, about five inches in diameter, sunk four feet in the sand, and standing out two feet, are being set in various places on these flats. The positions of the stakes are to be noted, distance, &c.; also the distance, on their different lines, from the outer one to the edge of the bar, at ordinary low water.

The amount of extension of Long Point into the harbor, I have no means of stating. A bar is evidently making out, but appears to have a tendency to carry on the general line of contour of the cape, and, as it advances, to curve itself inward. The stone placed on the outside of the "point," on the beach at the level of half-tide, and southwesterly from the light-house bulkhead, has probably (by catching the great amount of sand that it holds) retarded the increase of the bar, while adding to the thickness of the "point."

It appears to me that Provincetown Harbor requires an incessant watching of changes, as they progress, and that the steps of improvement should be exceedingly slow and cautious. What may seem a benefit to-day might prove an injury to-morrow. The light and cheap improvements proposed in your letter of December 21, 1868, to the Chief of Engineers, are undoubtedly necessary and would prove effective. Beyond them nothing could be done at present, unless, perhaps, if I

might venture to suggest, a few catch-sands be built in East Harbor, toward the head of the meadow, closing such hollow places as the "Cove," which might afford additional strength and at little cost.

The different works of improvement lately done by the United States were indubitably necessary, *i. e.*, stone on outside of Long Point, dike at High Head, and brush bulkhead and jetties on Beach Point, (all indicated on the map;) also, repairs on the older (plank) bulkhead, built by General Benham, Corps of Engineers, in 1866 and 1867, on the easterly portion of Beach Point, and with which the brush bulkhead is connected, running westerly. Of their necessity I am fully convinced, by frequent examinations of the increase of the danger which the dike is intended to avert, and of the increase of the safety which the rest of the works are producing.

A few sketches, in connection with the dike and brush bulkhead, will be furnished soon.

Mr. W. T. Martin, as draughtsman, &c., has been a very valuable assistant, and has discharged his various duties with great skill and fidelity.

I am, general, very respectfully, your obedient,

GEORGE BURROUGHS,
Capt. of Engineers and Bvt. Maj. U. S. A., Assistant.

Bvt. Maj. Gen. J. G. FOSTER,
Lieut. Col. of Engineers U. S. A.

S 3.

BOSTON, MASS., *May* 4, 1869.

GENERAL: I have the honor to enclose herewith the report of Brevet Lieutenant Colonel G. L. Gillespie, captain of engineers, of the survey made of Gangway Rock, Newburyport Harbor, Massachusetts, as directed by you.

In consequence of the freshet prevailing in the Merrimac River at the time of the survey, Colonel Gillespie found it impossible to properly conduct the survey with the crew of the General Humphreys, and was compelled to incur additional expenses by hiring a scow and five laborers.

* * * * * * * * *

The survey was made much more complete than I could expect, from the fact that Mr. Townsend, the submarine diver, accompanied the party, and descended to the rock in his armor, and assisted materially in the progress of the work. These services were rendered gratuitously by Mr. Townsend.

By reference to a tracing, which I forward herewith, showing the contour of the rock, the completeness of the survey will be seen.

The estimated expense of the removal of the obstructions referred to by Colonel Gillespie is as follows:

For Gangway Rock: Drilling, blasting, removing, and depositing on shore 45 cubic yards of rock, at $50 per yard	$2,250 00
For blasting and removing the wreck of the coal schooner near the Black Rocks	5,000 00

For contingencies, supervision, office expenses, &c., 15 per cent	$1,087 50
Total	8,337 50

I remain, general, very respectfully, your obedient servant,

J. G. FOSTER,
Bvt. Maj. Gen. U. S. A., Lieut. Col. Engineers.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers, Headquarters Corps of Engineers,
Washington, D. C.

UNITED STATES ENGINEER OFFICE,
City Hall, Boston, Mass., May 4, 1869.

GENERAL: I have the honor to submit the following report of my examination and survey of the Gangway Rocks, in Newburyport Harbor, Massachusetts:

In compliance with your verbal instructions I left Boston Friday morning, April 23, and immediatly after my arrival at Newburyport I looked up most of the pilots who were in and out of the harbor almost daily, and got their views in reference to the dangerous localities in the harbor. I also had interviews with some of the principal ship-owners; their statements generally coincided as to the obstacles, but differed as to the dimensions and dangers of the obstacles. The channel to the city is not especially tortuous, but there are several places where the greatest vigilance must be exercised by the pilot. The first of these, estimating from the bar, is an old wreck that lies off the Black Rocks. It is filled with coal, or was when it went down, in the fall of 1867, and has but six feet of water over it at low water. It lies directly in the channel and is most dangerous in its character. The pilots state that since it foundered it has risen two feet, probably due to part of the cargo having been emptied out by the currents. The next obstacle is the Gangway Rock, which I was directed to survey, and plans and sections of which accompany this report. It is in the channel, east of the north and south piers, and is particularly dangerous, as it is small and not abrupt and sharp on the channel side. On account of the ledge that runs out from the north pier, vessels passing have to hug the Gangway Rocks, and if by any mischance the tides and winds are unfavorable, they are liable to be thrown upon the Gangway. It is a hump of a general ledge that underlies the harbor, outcropping in another direction, it is supposed, at the Half-tide Rocks that lie south of the north and south piers. If the north pier ledge be partially blasted away in connection with the Gangway Rock, the channel will be sufficiently improved for all the purposes of facility of navigation. There is also a round boulder, with six feet of water at low water, near the south pier and in the inside, but it is so close to the pier that it is little to be feared. The position of this rock I have from report only. When I made the survey of Gangway Rock, the ordinary current of the Merrimac River had received an increment from the spring freshet, and it was not an easy matter to maneuver a boat near the piers. I could not take the Humphreys with any safety into that narrow channel where the current was rapid and the rocks not buoyed out, so I was forced to procure two small boats and from them locate the rock, which I buoyed as soon as found. This was done Friday afternoon. Next morning at high water, when the current was somewhat checked, I towed with the Humphreys two

scows I had engaged, and placed them in position over and inclosing the rock and made a partial survey that was completed on Monday following. Mr. Townsend, the submarine diver, examined the rock, with his armor on, Monday morning whilst I was taking soundings. I estimate that forty-five cubic yards blasted from the ledge will give the same depth of water as is found at other points of the channel between the piers—nine feet at low water.

I am, general, very respectfully,

G. L. GILLESPIE,
Captain of Engineers, Bvt. Lieut. Col. U. S. A.

Bvt. Maj. Gen. J. G. FOSTER, U. S. A.,
Lieutenant Colonel of Engineers.

I have forgotten to mention that near the custom-house wharf, a few rocks called the "Boilers" show themselves at low water; they are dangerous, but lie so near in-shore that but few vessels ever strike them.

G. L. G.

APPENDIX T.

BOSTON, MASS., *August* 18, 1869.

GENERAL: I have the honor to make the following report of operations on the sea walls of Great Brewster Island for the year ending June 30, 1869.

In my last annual report (of August 22, 1868) I reported the completion of all the main sea walls, as far as required for the protection of the south head, as also that the main wall itself was built, as far as had been designed, for the protection of the north head of this island. Although, from the increase of cost of work by contract over the estimate by hired labor, the funds had not sufficed to back with earth the last five hundred and fifty feet of this wall, or to set the rough "shells" stone paving in rear, as required for nearly the entire length of this wall.

For the completion of these portions of the work, I was advised, in September, that the estimated funds, $10,000, would be allotted, and the work was at once commenced and pushed as vigorously as possible through the remainder of the season, of which there then remained but some six or eight weeks of good working weather, and, during the autumn, the heavy rear paving on the main exposed easterly face was placed, for some fifteen feet back of this wall, upon one or two feet of small boulders or "shingle" for about seven hundred linear feet, completing the protection required for the most exposed part of the wall. The earth backing required has been filled in on the north short face of about one hundred and fifty feet, and on the next adjacent face of two hundred and fifty running feet at the northwest, and it was for the most part completed for the next and last face (of one hundred and fifty running feet) of the wall, and for nearly the whole distance around, some eight hundred running feet, from the termination of the heavy "shells" paving nearly to the face last named; a covering of small cobble stones or boulders was placed to afford a temporary protection from the dash of the sea, until the more reliable, heavy "shells" or large boulder paving (as at Lovell's Island) can be placed.

A good jetty of upright split stone, six to eight feet in height and about six to eight feet in breadth, and extending out obliquely about thirty feet from the west end of the wall of the south face of the south head, was also built; the jetty being sunk one-half its depth in the blue

clay, and surrounded at the base with concrete of two and one-half to three feet in height and width. This appears to secure, effectually, the extremity of the wall from that of the eddying sea.

A dry wall, of three courses of stone on hand, was laid to give a temporary protection to the gap between the north and south head walls.

From the lateness of the season at which the funds were available and the early setting in of the winter, it was impossible to finally complete the work required for the rear of the north head wall, although the funds allowed, if used in the more favorable weather of the midsummer, would have sufficed for this purpose. And though some, nearly one-fourth, remained on hand, it was not deemed advisable to commence work there this season until a decision was had as to my estimates for $25,000 for constructing a wall (of two hundred and fifty running feet) between the two walls already built. That sum having been allotted in June, the quarrying and dressing and delivery of the stone facing required (having been previously arranged for conditionally) was at once ordered, and now, at this date, within the past ten days, some three cargoes have been delivered and the work for closing this gap has been vigorously commenced, and it is expected that this wall, with all the work remaining to completely protect the north head, with two or three jetties at the angles—in fact, all that now appears to me to be necessary for the protection of the island—will be completed by the close of the working season, and no further funds are at present thought necessary.

The work of the fiscal year (executed last autumn) comprised the setting of the heavy "shells" stone paving in rear for about seven hundred running feet, including the whole of the main most exposed portion of the east face of the north head, the filling in rear with earth of about four hundred running feet, from the northeast angle to the west and northwest parts, and the placing of the greater part of this earth filling at the back of the last northwest face, (of about one hundred and fifty running feet,) the covering of nearly all the completed earth filling with small boulders as a temporary protection against the dash of the sea, and the construction of a strong stone pile jetty, sunk one-half in the clay and surrounded with a good base or offset of concrete, to protect the west corner of the wall of south head, and a dry wall, some six feet high, was placed to give temporary protection to the bank of drift between the walls of the two heads.

The following is the statement of the funds available and expended during the year ending June 30, 1869, for Great Brewster Island:

On hand July 1, 1868, from direct appropriation	$547 85
Received during the year from appropriation for "repair, preservation, extension, and completion of certain public works on rivers and harbors"	10,000 00
Allotted from appropriation for "improvement of rivers and harbors"	25,000 00
	35,547 85
Expended during the year	8,625 87
Remaining available July 1, 1869	26,921 98

I am, general, very respectfully, your most obedient,

H. W. BENHAM,
Brevet Major General.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers.

BOSTON, MASS., *August* 23, 1869.

GENERAL: I have the honor to make the following report of operations on the sea walls of Deer Island and Lovell's Island, for the year ending June 30, 1869.

For the wall on Deer Island, my last previous report had given the amount of wall rebuilt up to the close of the fiscal year, to wit: about 420 feet of wall (the whole) at the south head, 540 running feet, all immediately requiring repairs upon the middle head, and 206 linear feet on the north head, being the commencement of work as reported, under a contract for rebuilding all that was necessary on this north head; the whole amount of wall thus rebuilt being 1,166 running feet since I had charge of the works.

This contract, as stated in that report, required the completion of the work on the north head during that, the last working season. But my fears of delay as there stated were realized by the operations being protracted into the present season. Nearly 600 running feet of wall, however, including the backing with concrete of about fifty feet of a former repair, were rebuilt during the season, after the commencement of the fiscal year, which connected the work with the principal repair (of 250 feet in length) made by Colonel Graham in 1865.

In May of this year the work was commenced by the contractor at the north end of the part repaired by Colonel Graham, and by the close of the fiscal year about 380 running feet of wall were rebuilt and nearly completed as to the backing and paving in rear, being nearly all that the funds on hand would permit; much additional contingent expense having been incurred by the delay of the works into the present season.

At the date of this report this wall is essentially completed, as far as the funds allow, and two stone pile jetties have been placed to protect the foundations, one near the middle of the wall of the north head, and the other near the center of the main face of the wall of the middle head. The whole amount of sea wall rebuilt on the north head by the contractor is about 1,200 running feet, while, in addition, a concrete backing to about 50 feet has been added to a former repair.

Had the funds sufficed, I should have judged it to be expedient to rebuild, perhaps, some 250 feet more of this wall, and to re-enforce or back with concrete the 250 feet of the repairs of 1865, which I doubt not will be needed for its security. And although there are not at this time any very defective places or parts requiring immediate repair, I should judge that a further sum of $8,000 would be advantageously expended in giving other parts of the old wall of this north head the strength and security from future injury of the parts now rebuilt.

And as to the walls on Lovell's Island, in my last annual report it was stated that contracts had then recently been made for some repairs to be given to the wall of the north head, and for the construction of a new wall of about 800 running feet to protect the southeast bluff, the stone for which, by a contract of the previous year, 1867, had mostly been delivered and was near the site of the wall.

This wall of the southeast bluff is in a less exposed situation than that of the north head, though one more open to the sea than any other as near the main channel, except at Long Island head. I had planned for the minimum of material and expense that I thought possible to use, and it has been planned and built with about twenty-five per cent. less of cross-section and height than that model and successful work of General Thayer, built some thirty-five years ago, at the north head of this island. This wall was arranged to protect the about 800 feet

the length of the bluff with a middle face of 250 feet, and one of 200 running feet at each end of this thrown back to the shore about three degrees, with wing walls of some 50 to 60 feet, at angles of forty-five degrees to the banks at the outer extremities of these last faces. The wall was laid about three feet in the clay below, and some 10 to 20 feet without the high water-line; the foundation having two feet rise, by 6 feet 6 inches width, and the wall above of four courses, 8 feet of stone facing with concrete backing, 5 feet six inches in width, the three lower courses being of headers and stretchers with cut dovetailed joints, bed and builds, and the coping of four feet in width by two feet in height, with indented joints; that is, alternately of double dovetailed headers, and of lozenge, or rather truncated lozenge-shaped stone binding the whole course together against the displacement of any single stone. This device had occurred to me many years ago, though I have not tried it previously, and the wall and coping after being well backed up with earth was paved in the rear, for some 15 feet in width, with good-sized boulders, as the least expensive protection; and the four angles of the face of the main wall were protected with stone pile jetties 6 to 8 feet wide, projecting obliquely about 25 to 27 feet outward. The piles of 6 to 8 feet height are sunk one-half in the clay of the sloping shore, and have a base or offset of concrete in this clay, 2½ to 3 feet in cross-sections on both sides and at the end.

This wall was commenced, as agreed upon, in July of last year, and steadily carried on to its completion, as above described, by the month of December, and I have the pleasure of reporting it, after a recent examination, as answering the purpose desired in the most satisfactory manner possible. It is, in fact, more perfect now—more consolidated in rear and more filled up by shingle in front even to half its height—than the day it was finished, while it appears to be of ample height to give all the protection required.

From the early closing of the last autumn season, the required repairs were not given to the wall of the north head; but in May of this year, these were essentially completed by the placing of two stone pile jetties (of the character of those placed at the angles of the new wall of the southeast bluff) upon the most exposed and most injured portions of this north head wall, at its convex part, near the east end, one jetty being placed about 100 feet from the east extremity of the wall, and the other about 125 feet further to the west. The foundation of the wall between the jetties, and on either side for some 40 feet, or for 150 feet altogether, was secured by an apron facing of upright stone piles, sunk some 3 feet in the clay, with an outside protection of concrete 2½ feet wide and deep, the piles rising to the first or second courses of the stone facing of the main wall.

Some further repairs would have been given to the jetty at the west end of the north head wall had the necessary stone been on hand, and the funds available. But in the want of this, and the necessary protection having been given to the parts most injured on the wall of this head, the work was closed by June of this year.

The following is the statement of funds available and expended during the year ending June 30, 1869, for both works:

On hand July 1, 1868, from direct appropriation	$2,515 30
On hand July 1, 1868, from appropriation for "improving harbor at Boston"	5,000 00
	7,515 30

Received from United States treasury during the year, from appropriation for "improving harbor at Boston"	$43,000 00
	50,515 30
Expended during the year	43,245 16
Remaining available July 1, 1869, in sub-treasury........	7,270 14

I am, sir, very respectfully, your most obedient,

H. W. BENHAM,
Brevet Major General.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers.

CUSTOM-HOUSE, BOSTON,
Collector's Office, August 24, 1869.

SIR: I am in receipt of your communication of the 20th instant, and in answer to your inquiries would state as follows:

1. The amount of revenue collected at this port during the year ending June 30, 1869, was $18,076,566 97.

2. The number and tonnage of vessels which entered at this port during the year ending June 30, 1869, are—

In the foreign trade, number	3,496
Coastwise, number	1,505
	5,001
In the foreign trade, tons.............................	777,159
Coastwise, tons.....................................	1,106,986
	1,884,145

The "coastwise" does not include vessels in the coastwise trade sailing under a license. Of these there are about 300, making several trips during the year.

The number of tons registered, enrolled and licensed vessels, for the year ending June 30, 1869, was about three hundred and forty thousand tons, new measurement.

It is safe to say, that during the past year fourteen thousand vessels arrived and sailed from Boston Harbor. Their capacity may be estimated as at least two millions of tons. All these are benefited by the improvements in and about Boston Harbor.

Very respectfully, your obedient servant,

THOMAS RUSSELL, *Collector.*

APPENDIX U.

I.—*Report on the Saco River improvements, for the year ending June* 30, 1869, *by Brevet Brigadier General George Thom, lieutenant colonel of engineers.*

The plan, which has received the approval of the department, for the improvement of Saco River, consists in the rebuilding of some of the

most important piers in the river, the removal of sunken rocks near "Little Islands," and the construction of a breakwater near the mouth of the river.

The appropriations and allotments made for these works up to the 30th of June, 1869, are as follows, viz:

1. Appropriation by act of Congress, approved June 23, 1866	$40,000 00
2. Appropriation by act of Congress, approved March 2, 1867	40,000 00
3. Amount allotted by department, September, 1868, from the appropriation "for the repair, preservation, extension, and completion of certain public works on rivers and harbors," approved July 25, 1868	20,000 00
4. Amount allotted by department in May, 1869, from the appropriation "for the improvement of rivers and harbors," approved April 10, 1869	22,500 00
Total	122,500 00

The work done under the first two appropriations, (viz., $80,000,) up to the close of the fiscal year ending June 30, 1868, is as follows: An accurate hydrographic survey made of the river, from Saco down, to include the islands in the ocean off the mouth of the river; a removal of a greater portion of the sunken rocks from the channel near "Little Islands;" and the partial construction of the breakwater, extending from the mouth of the river out as far as the "beacon," (on the old outer pier,) being a distance of 2,550 feet.

The stone for this breakwater was obtained under a contract made with Messrs. James M. Deering and John W. Deering, of Saco, Maine, for furnishing 50,000 tons, more or less, of stone, deposited in the work for $1 81 per ton of 2,240 pounds; and, at the close of the fiscal year ending June 30, 1868, the contractors had furnished 39,270 tons under their contract. On the 3d of July, 1868, (in the present fiscal year,) a total of 40,223 tons had been delivered, when operations on this work were suspended for want of funds.

On the 10th of July, 1868, a contract was made with Mr. Reuben Wiley, jr., of Seabrook, New Hampshire, in acceptance of his bid for removing still another and the only remaining sunken rock in the channel near "Little Islands," which was satisfactorily completed on the 1st of August, at a cost of two hundred dollars.

On being advised (in September, 1868) of the allotment to this work of $20,000, out of the appropriation for "the repairs, preservation, extension, and completion of certain river and harbor works," operations were at once resumed under the contract with Messsrs. Deering, and applied to the partial completion of that portion of the work already in progress, as well as to its necessary extension out to the "spit" beyond the old outer pier, for a distance of 1,450 feet beyond the "beacon," (at the inner end of this pier,) making a total distance of 4,000 feet from the shore.

On the 28th of October, 1868, the contractors completed their contract, having furnished up to that period $51,223\frac{85}{112}$ tons of stone for the work, whereby the additional amount of $20,000 allotted to the work was exhausted.*

*It is due to the contractors, Messrs. James M. Deering and John W. Deering, to state that this contract was performed in a very expeditious, satisfactory, and creditable manner throughout.

The progress made in the improvement of the river, at the close of the fiscal year ending June 30, 1869, consists, therefore, in the removal of all the sunken rocks from the channel near "Little Islands," which rocks were the greatest and most dangerous obstructions to its navigation; and in building a breakwater at the mouth of the river. This breakwater has been carried (in partial completion) from its shore end out to the "beacon," (on the inner end of the old outer pier,) being a distance of 2,250 feet, and up to a general level of nine feet above mean low water, (being about mean high water,) with an average thickness of about twenty feet.

From the "beacon," it has been extended outward to the "spit," for a distance of 1,450 feet, making its total length 4,000 feet. This portion outside the "beacon" forms but the "core" of the proposed work, and is barely sufficient to divert the channel as required, or to withstand the violent storms to which it is exposed.

This work, in its present unfinished condition, has accomplished all that was expected from it. It has closed the old channel, (as was intended,) and formed a new one, (as was expected,) much more uniform and direct along the inside of the breakwater, and as far out as it extends, and it is apparently rapidly improving beyond that point; so that vessels now enter through the new channel in a much more direct course and drawing more water by about two feet than was before practicable.

The allotment of $22,500 made in May, 1869, for the improvement of Saco River, it is proposed to apply, so far as it goes, toward the completion and extension of the present breakwater, and proposals have been invited until the 22d of July for furnishing the stone required for the work.* The amount allotted to it will probably be expended before the 1st of November next. But in order to fully realize the benefits to be derived from the completion of this important work, and make it effectual in opening a direct, uniform and permanent channel out to deep water, it will have to be still further increased in height, thickness, and length; for which purpose there will be required, as per previous estimates, (exclusive of the estimate for capping,) the sum of $40,000, and for rebuilding the old piers in the river the additional sum of (see estimates in previous annual reports) $19,200, making a total (exclusive of estimate for capping) of $59,200, or say $60,000, which amount can be profitably expended during the next fiscal year.

Amount of appropriations available June 30, 1868	$4,132 48
Amount received by allotment in September, 1868	20,000 00
Amount received by allotment in May, 1869	22,500 00
Total	46,632 48
Amount expended during the fiscal year ending June 30, 1869	23,997 06
Amount available June 30, 1869	22,635 42

The works for the improvement of Saco River are located in the collection district of Saco, near the ports of Saco and Biddeford, Maine.

The nearest light-house is on Wood Island, opposite the mouth of

* A contract for this work was made on the 22d of July with Mr. Isaac Hamilton, of Cumberland, Maine, under which operations were commenced the first of August, and on the 15th of September, 1869, 8,698½ $\frac{640}{2240}$ tons of stone were delivered upon the breakwater by him, making a total of 59,922¼ tons delivered upon the work up to that date.

Saco River; and the nearest forts are those in Portland Harbor, about fifteen miles distant.

The amount of revenue collected at Saco, (the port of entry,) as furnished by the collector, was, for the fiscal year ending June 30, 1869, $1,158 87. This port is the entry for the supplies of a population of about thirty thousand, including the back districts, and is the natural shipping port for the timber interests of nearly the whole of York County, except some towns in the extreme western part, which lie near Portsmouth, New Hampshire.

At the inner harbor, which is inside the "bar," the arrivals have amounted in one year to about forty coal vessels, and from one hundred and fifty to two hundred vessels engaged in the coasting trade, bringing general merchandise for Saco, Biddeford, and the back country, and carrying out timber, ice, &c., exclusive of what is transported by railroad. This trade will, doubtless, be very largely increased by the proposed improvements in the navigation of the river.

The improvements already made and now in progress may be regarded as permanent, and such as, after completion, will not require further expenditure.

The papers, described as follows, are hereto appended, viz:

1. Abstract of bids received, with names of bidders.
2. Abstract of contracts, with names of contractors.

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 1, 1869.

Abstract of bids received for the improvement of Saco River, Maine.

Nature of work.	Name of bidder.	Amount bid for.	Price.
For removing sunken rock	Reuben Wiley, Seabrook, N. H.	Whole work.	$200 00

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

Abstract of contracts made for the improvement of Saco River, Maine.

Nature of work.	Name of contractor.	Quantity.	Price.
For removing sunken rock	Reuben Wiley, Seabrook, N. H.	Whole work.	$200 00

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

II.—*Report on the extension of the breakwater and otherwise improving the harbor at Portland, Maine, for the year ending June* 30, 1869, *by Brevet Brigadier General George Thom, lieutenant colonel Corps of Engineers.*

By an act of Congress approved June 23, 1866, an appropriation was made "for extending the breakwater at Portland Harbor Maine," amounting to $105,111 05. This work consisted in the completion of

the capping of 733½ running feet of the unfinished portion of the work, and its extension in such a manner as might be determined on by the department.

Preparatory to deciding on any plan for its extension, a complete and accurate resurvey of the harbor has been made, together with a full series of tidal and current observations, at such points in the harbor as might be found useful in arriving at proper conclusions.

Operations on the breakwater have, therefore, been hitherto confined to the unfinished capping, which was completed on the 20th of August, 1868, under three separate contracts* made as follows: 1st, August 9, 1867, with Messrs. Pierce & Rowe, of Frankfort Mills, Maine, for "furnishing the stone," at $24 45 per running foot of the breakwater; 2d, August 6, 1867, with Mr. George P. Wescott, of Portland, Maine, for "performing the labor," at $11 per running foot of breakwater; 3d, August 6, 1867, with Messrs. Charles Staple & Sons, of Portland, Maine, for furnishing composition bolts, at 39 cents per pound.

By a joint resolution of Congress approved June 5, 1868, it was resolved "that so much of the unexpended balance of the appropriation for the breakwater in Portland Harbor, Maine, as the Chief Engineer shall deem proper, may be expended under his direction in excavating the 'middle ground' near said breakwater, and in otherwise protecting the channel from injury, by filling and improving the same." Under instructions from the department, in furtherance of the joint resolution referred to, proposals were invited on the 6th of July, 1868, for dredging near the "middle ground," and four bids were received, ranging from 34 to 50 cents per cubic yard. Messrs. A. B. Cooley & Co., of Philadelphia, Pennsylvania, were the lowest bidders for the work, at 34 cents per cubic yard, and accordingly a contract, dated July 23, 1868, was made with them and approved by the department, for completing the work not later than 30th of November, 1868. They commenced operations on the 13th of August, and after excavating 4,370 cubic yards, abandoned their contract.

As instructed by the department, I again on the 8th of October, and afterward on the 13th of October, invited proposals for "dredging the bar near the middle ground" and for "dredging the spit opposite the Grand Trunk wharves, above and near the middle ground." All the proposals for the "middle ground bar," being unreasonably high, were rejected; in consequence of which the work had to be deferred until a more favorable time for such operations, in the spring.

A contract was made, with the approval of the department, on the 21st of December, 1868, with Mr. Augustus R. Wright, of Hallowell, Maine, (Mr. Boschke, who was the lowest bidder for the work, having declined entering into a contract therefor,) for dredging the "spit" opposite the Grand Trunk wharves, at 60 cents per cubic yard.

The work was completed on the 13th of May, 1869, thus affording a channel of 100 feet in width at its inner end, opening out to about 200 feet at its outer end, and 20 feet in depth, at mean low water, through the "spit" up to the wharves of the English steamers.

Under instructions from the department, dated the 3d of April, 1869, proposals were again invited, on the 7th of April, and afterward on the 5th of May, 1869, for "dredging the bar near the middle ground;" making in all five series, of 24 bids, received for this work, from various parties in New England, New York, and Pennsylvania, at prices ranging from 34 cents to $1 12 per cubic yard, as will be seen by the accompanying

*The abstracts of these bids and contracts accompany the annual report for year ending June 30, 1868.

"abstract of bids." Of the last series of bids received, that of Messrs. Morris & Cumings, of New York City, was the lowest, at 56 cents per cubic yard, and a contract was accordingly made, on the 21st of May, 1869, with them for completing the work on or before the 1st of November next.*

The channel through the "middle ground bar" is to have a depth of 20 feet at mean low water, or 29 feet at mean high water, with an average width of not less than 200 feet, and will probably be completed in the time required by the contract.

The available balance of the appropriation on the 30th of June, 1868, was	$79,397 87
Amount expended during the fiscal year ending June 30, 1869	14,906 05
Amount available July 1, 1869	64,491 82

which amount can be profitably expended upon the opening of the channel through the "middle ground bar."

Additional amount required for the proposed extension of the breakwater, as heretofore estimated for, $40,000; which amount can be profitably expended upon the work during the fiscal year ending June 30, 1871.

The following information, called for by the acts of Congress making appropriations for this work, is supplied, viz:

These works of improvement are situated in Portland Harbor, Maine.

There is a light-house on the outer extremity of the present breakwater, and another at the outer entrance into the harbor called "Portland Head light," and Forts Gorges, Preble, and Scammell, are all located in this harbor.

The amount of revenue collected at this port for the fiscal year ending June 30, 1869, (as stated by the United States collector of customs,) is as follows, viz:

Duties on importation	$959,534 49
Duties, tonnage and hospital	19,832 88
Total	979,367 37

"A large part of the commerce of this port consists of goods entered here for transportation and exportation, and the amount of duties assessed on goods entered at this port for the last fiscal year was $9,075,998 39.

"The foregoing statements indicate the amount of foreign commerce at this port, and show that it is very large. The number of vessels (foreign and domestic) entered the last fiscal year was 1,248; the number, in the harbor of the port, as a place of refuge and for other purposes, was over 4,000.

"With the opening of the railroads, the construction of which will begin this year, the commerce of this port will undoubtedly be largely increased."

The improvements proposed for the extension of the breakwater, when completed, may be regarded as permanent.

The opening of the channel through the "middle ground bar" may have to be repeated to some extent, at some future time, but when and to what extent cannot now be foreseen.

* Messrs. Morris & Cumings commenced operations on the 6th of July, and on the 3d of September had excavated 30,000 cubic yards under their contract.

The several papers, described as follows, are hereto appended, viz:

1. Copies of advertisements inviting proposals for dredging, (marked A, B, C, D, and E.)
2. Abstract of proposals for same, with names of bidders, (marked F.)
3. Abstract of contracts for same, with names of contractors, (marked G.)
4. Copy of instructions from the Chief of Engineers as to the manner of improving the harbor by dredging, (marked H.)

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 1, 1869.

A.—*Proposals for dredging in Portland Harbor, Maine.*

Proposals will be received at this office until 3 o'clock p. m. on Monday, the 20th instant, for dredging sixty thousand cubic yards, more or less, near the "Middle Ground," so as to obtain a depth of twenty feet at mean low water.

The work must be commenced as soon as practicable after the approval of the contract, and be completed not later than the 30th of November next. The material excavated (which borings indicate to be soft mud) is to be deposited in localities not exceeding three miles in distance from the work, to be designated by the engineer in charge.

Bidders will state the price per cubic yard of excavation, as measured in the scows, including also the removal of the material to the localities designated.

Payments will be made monthly; twenty per cent. to be reserved therefrom, until the whole work is satisfactorily completed, and to be forfeited in the event of non-fulfillment of the contract in the time and manner required.

The undersigned reserves the right to reject all bids which, in his opinion, are not favorable to the government; also the bid of any person who there is reason to believe will not faithfully and promptly perform the contract.

Persons desiring to make proposals are requested to call on the undersigned, at his office in Morton Block, on Congress street, for forms of same, and for more definite information if desired; and on transmitting their bids will indorse thereon "Proposals for dredging in Portland Harbor."

GEO. THOM,
Brevet Brigadier General U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 6, 1868.

B.—*Proposals for dredging in Portland Harbor, Maine.*

The contractors for this work having failed to comply with their contract, proposals will again be received at this office until 3 o'clock p. m. on Monday, the 19th instant, for dredging sixty thousand cubic yards, more or less, on the bar near the "Middle Ground," in this harbor, so as to obtain a depth of twenty feet at mean low water.

The work must be commenced and completed at the earliest period practicable. The material to be excavated is to be deposited in such

localities as the superintending engineer may designate, not exceeding three miles in distance from the work.

Bidders will state the price per cubic yard of excavation, as measured in the scows, including also the removal of the material to the designated localities; also, the time in which they will complete the work, as this will give a preference in the acceptance of bids, it being important that the work should be done as soon as practicable.

Separate proposals will also be received until the same period for dredging five thousand cubic yards, more or less, as measured in the scows, to the depth of twenty feet at mean low water on the "Spit" off the Grand Trunk wharves, above and near the "Middle Ground," the material excavated to be deposited as required above, and the work to be completed not later than the 15th of December next.

Payments will be made monthly; twenty per cent. to be reserved therefrom until the whole work is satisfactorily completed; and to be forfeited in the event of the non-fulfillment of the contract in the time and manner required.

The undersigned reserves the right to reject all bids which, in his opinion, are not favorable to the government; also, the bid of any person who there is reason to believe will not faithfully and promptly perform the contract.

Persons desiring to make proposals are requested to call on the undersigned at his office, in Morton Block, on Congress street, for forms of same and for more definite information as to the locality, depth, and character of dredging; and on transmitting their bids (which are required to be in duplicate) they will please indorse thereon, "Proposals for dredging the bar near the Middle Ground," or the "Spit near the Middle Ground," as the case may be.

GEO. THOM,
Brevet Brigadier General U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, October 8, 1868.

C.—*Proposals for dredging in Portland Harbor, Maine.*

Proposals will again be received at this office until 3 o'clock p. m. on Monday, the 9th of November next, for dredging sixty thousand cubic yards, more or less, on the bar near the "Middle Ground," in this harbor, so as to obtain a depth of twenty feet at mean low water.

The work must be commenced and completed at the earliest period practicable. The material to be excavated is to be deposited in such localities as the superintending engineer may designate, not exceeding three miles in distance from the work.

Bidders will state the price per cubic yard of excavation, as measured in the scows, including also the removal of the material to the designated localities; also, the time in which they will complete the work, as this will give a preference in the acceptance of bids, it being important that the work should be done as soon as practicable.

Separate proposals will also be received until 3 o'clock p. m. on Thursday, the 5th of November, for dredging five thousand cubic yards, more or less, as measured in the scows, to a depth not exceeding twenty feet at mean low water on the "Spit" off the Grand Trunk wharves, above and near the "Middle Ground," the material excavated to be deposited as required above, and the work to be completed not later than the 15th of December next.

Payments will be made monthly; twenty per cent. to be reserved therefrom until the whole work is satisfactorily completed; and to be forfeited in the event of the non-fulfillment of the contract in the time and manner required.

The undersigned reserves the right to reject all bids which, in his opinion, are not favorable to the government; also, the bid of any person who there is reason to believe will not faithfully and promptly perform the contract.

Persons desiring to make proposals are requested to call on the undersigned at his office, in Morton Block, on Congress street, for forms of same and for more definite information as to locality, depth, and character of dredging; and on transmitting their bids, (which are required to be in duplicate,) they will please indorse thereon, "Proposals for dredging the bar near the Middle Ground," or the "Spit near the Middle Ground," as the case may be.

GEO. THOM,
Brevet Brigadier General U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, October 31, 1868.

D.—*Proposals for dredging in Portland Harbor, Maine.*

Proposals will be received at this office until 3 o'clock on Monday, the 19th instant, for dredging the bar near the "Middle Ground," in this harbor, so as to obtain a depth, at mean low water, of nineteen or twenty feet, as may be hereafter determined by the engineer in charge. The depth of excavation will not exceed three feet for a nineteen-foot channel, and the amount to be excavated will be fifty thousand cubic yards, more or less; for a twenty-foot channel the depth of excavation will not exceed four feet, and the amount to be excavated will be seventy-five thousand cubic yards, more or less—the amount in both cases depending upon the width of the channel, as may be decided on to be excavated.

The work must be commenced as soon as practicable after the approval of the contract, and be completed not later than the 15th day of November next.

The material excavated is to be deposited in such localities, not exceeding three miles in distance from the work, as the superintending engineer may designate.

Bidders will please state the price per cubic yard of excavation, as measured in the scows, including also the removal of the material to the localities designated; first, for a channel of nineteen feet depth at mean low water; and second, for a channel of twenty feet depth at mean low water.

Payments will be made monthly; twenty per cent. will be reserved therefrom until the whole work is satisfactorily completed, and be forfeited in the event of the non-fulfillment of the contract in the time and manner required.

The undersigned reserves the right to reject all bids which, in his opinion, are not favorable to the government; also, the bid of any person who, there is reason to believe, will not faithfully and promptly perform the contract.

Persons desiring to make proposals are requested to call on the undersigned at his office, in Morton Block, on Congress street, for forms of same and for more definite information as to the locality, depth, and

character of dredging; and on transmitting their bids (which are required to be in duplicate) they will please indorse thereon, "Proposals for dredging the bar near the Middle Ground."

GEO. THOM,
Brevet Brigadier General U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, April 7, 1869.

E.—*Proposals for dredging in Portland Harbor, Maine.*

Proposals will again be received at this office until 10 o'clock a. m. on Saturday, the 15th instant, for dredging the bar near the "Middle Ground," in this harbor, so as to obtain a depth, at mean low water, of nineteen or twenty feet, as may be hereafter determined on by the engineer in charge. The depth of excavation will not exceed three feet, for a nineteen-foot channel, and the amount to be excavated will be fifty thousand cubic yards, more or less; for a twenty-foot channel the depth of excavation will not exceed four feet, and the amount to be excavated will be seventy-five thousand cubic yards, more or less, the amount in both cases depending upon the width of the channel, as may be decided on, to be excavated.

The work must be commenced as soon as practicable after the approval of the contract, and be completed not later than the 15th day of November next.

The material excavated is to be deposited in such localities, not exceeding three miles in distance from the work, as the superintending engineer may designate.

Bidders will please state the price per cubic yard of excavation, as measured in the scows, including also the removal of the material to the localities designated; first, for a channel of nineteen feet depth at mean low water, and second, for a channel of twenty feet depth at mean low water.

Payments will be made monthly; twenty per cent. will be reserved therefrom until the whole work is satisfactorily completed, and be forfeited in the event of the non-fulfillment of the contract in the time and manner required.

The undersigned reserves the right to reject all bids which, in his opinion, are not favorable to the government; also, the bid of any person who, there is reason to believe, will not faithfully and promptly perform the contract.

Persons desiring to make proposals are requested to call on the undersigned at his office, in Morton Block, on Congress street, for forms of same and for more definite information as to the locality, depth and character of dredging; and on transmitting their bids (which are required to be in duplicate) they will please indorse thereon, "Proposals for dredging the bar near the Middle Ground."

GEO. THOM,
Brevet Brigadier General U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, May 5, 1869.

N. B.—The Portland Daily Press is the only newspaper authorized to publish the above notice.

GEO. THOM, *B. B. G.*

F.—*Abstract of bids received for extending the breakwater, Portland Harbor, Maine, applied to dredging in Portland Harbor.*

No. for reference.	Nature of work.	Name of bidders.	Amount bid for.	Price.
		FIRST SERIES.		
1	Dredging bar near the Middle Ground.	A. B. Cooley & Co., Philadelphia, Pa.	60,000 cubic yards, more or less.	34 cents per cubic yard.
2	......do	L. D. M. Sweat and David Boyd, Portland, Me.	60,000 cubic yards, more or less.	50 cents per cubic yard.
3	......do	A. Boschke, Boston, Mass.	60,000 cubic yards, more or less.	50 cents per cubic yard.
4	......do	James T. Hayden, Buffalo, N. Y.	60,000 cubic yards, more or less.	44 cents per cubic yard.
		SECOND SERIES.		
5	......do	Augustus R. Wright, Geneva, N. Y.	60,000 cubic yards, more or less.	75 cents per cubic yard.
6	......do	Asahel Clarke, Sandy Hill, N. Y.	60,000 cubic yards, more or less.	75 cents per cubic yard.
7	......do	Templeton & Payn, Albany, N. Y.	60,000 cubic yards, more or less.	75 cents per cubic yard.
8	......do	Charles S. DeGraw, Fulton, Oswego Co., N. Y.	60,000 cubic yards, more or less.	94 cents per cubic yard.
9	......do	Augustus R. Wright, Geneva, N. Y.	5,000 cubic yards, more or less.	75 cents per cubic yard.
10	......do	Charles S. DeGraw, Fulton, Oswego Co., N. Y.	5,000 cubic yards, more or less.	94 cents per cubic yard.
		THIRD SERIES.		
11	......do	Albert Boschke, Boston, Mass.	5,000 cubic yards, more or less.	55 cents per cubic yard.
12	......do	Augustus R. Wright, Hallowell, Me.	5,000 cubic yards, more or less.	60 cents per cubic yard.
13	......do	Augustus R. Wright, Hallowell, Me.	60,000 cubic yards, more or less.	65 cents per cubic yard.
14	......do	James T. Hayden, Buffalo, N. Y.	60,000 cubic yards, more or less.	69 cents per cubic yard.
15	......do	Asahel Clark, Sandy Hill, N. Y.	60,000 cubic yards, more or less.	75 cents per cubic yard.
		FOURTH SERIES.		
16	......do	Templeton & Payn, Alba- N. Y.	Channel 19 feet deep. Channel 20 feet deep.	75 cents per cubic yard. 70 cents per cubic yard.
17	......do	Charles S. DeGraw, Fulton, Oswego Co., N. Y.	Channel 19 feet deep. Channel 20 feet deep.	85 cents per cubic yard. 95 cents per cubic yard.
18	......do	William Rankin, Charlotte, Monroe Co., N. Y.	Channel 19 feet deep. Channel 20 feet deep.	$1 per cubic yard. $1 25 per cubic yard.
		FIFTH SERIES.		
19	......do	Morris & Cumings, New York City.	Provided 50,000 cubic yards are excavated. Provided 75,000 cubic yards, or over, are excavated.	58 cents per cubic yard. 56 cents per cubic yard.
20	......do	John Taggart, Boston, Mass.	Channel 19 feet .. Channel 20 feet ..	67½ cents per cubic yard. 67½ cents per cubic yard.
21	......do	Templeton & Payn, Albany, N. Y.	Channel 19 feet .. Channel 20 feet ..	75 cents per cubic yard. 70 cents per cubic yard.
22	......do	William Rankin, Charlotte, Monroe Co., N. Y.	Channel 19 feet .. Channel 20 feet ..	84 cents per cubic yard. $1 12 per cubic yard.
23	......do	Charles S. DeGraw, Fulton, Oswego Co., N. Y.	Channel 19 feet .. Channel 20 feet ..	85 cents per cubic yard. 95 cents per cubic yard.
24	......do	Rensden R. Dodge, Fulton, Oswego Co., N. Y.	Channel 19 feet .. Channel 20 feet ..	99 cents per cubic yard. $1 05 per cubic yard.

GEO. THOM,
Lieut. Col. Engineers, Brt. Brig. Gen. U. S. A.

G.—Abstracts of contracts made for dredging in Portland Harbor, Maine.

No. for reference.	Nature of work.	Name of contractors.	Quantity.	Price.
1	Dredging near the Middle Ground.	A. B. Cooley & Co., Philadelphia, Pa.	Whole work.	34 cents per cubic yard.
2	Dredging Spit	Augustus R. Wright, Hallowell, Me.	Whole work.	60 cents per cubic yard.
3	Dredging near the Middle Ground.	Morris & Cummings, New York City.	Whole work.	58 cents per cubic yard, provided 50,000 cubic yards are excavated; or 56 cents per cubic yard, provided 75,000 cubic yards are excavated.

GEO. THOM,
Lieut. Col. Engineers, Bvt. Brig. Gen. U. S. A.

H.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., April 3, 1869.

GENERAL: Your letter of March 27, in response to letter from this office of the 24th, in reference to the improvement of the harbor of Portland by dredging, has been received.

As to the manner in which this work should be done, viz., by contract, or by purchase of machinery, employing hired labor, it has been determined, in view of all the circumstances attending this question, that it would be more advantageous to have the dredging done by contract, provided reasonable prices be offered. There being at present no appropriation available for similar works of improvement within your district, the whole cost of the necessary machinery and apparatus must be paid out of the appropriation for Portland Harbor, and since the amount of the appropriation remaining after the purchase money (including the right to use the machinery) has been paid, is limited, and as there is not much prospect of any money being appropriated for these other works, it is the opinion of the Chief of Engineers that the public interest will be best subserved by advertising anew for proposals, to open a channel of the required depth through the "middle ground" or bar.

In your letter of June 30, 1868, you submit two estimates of probable cost of this work, for a channel three hundred feet wide, one with a depth of nineteen feet at mean low water, and the other of twenty feet. These estimates of cost were based upon the rate of forty cents per cubic yard.

It is suggested, on account of the increased cost per yard, that in advertising for proposals separate bids will be received for the two depths, nineteen feet, and twenty feet, and that the width of the channel is to be determined by the engineer in charge as the work progresses, to be not less than one hundred and seventy feet, and not more than three hundred feet.

By command of Brigadier General Humphreys.

Very respectfully, your obedient servant,

JNO. G. PARKE,
Maj. of Engineers, Bvt. Maj. Gen. U. S. A.

Bvt. Brig. Gen. GEORGE THOM,
Lieut. Col. of Engineers, Portland, Maine.

III.—*Report on the improvement of Kennebec River, between Shepard's Point and Augusta, Maine, for the year ending June, 30, 1869, by Brevet Brigadier General George Thom, lieutenant colonel Corps of Engineers.*

The plan now in progress for the improvement of the navigation of this river consists in straightening and deepening its channel by dredging through the several shoals, and the removal of rocks which obstruct it between Gardiner and Augusta, Maine. This channel was completed on the 29th of September, through Hallowell's Shoal and Shepard's Point Shoal, having a width on its bottom of seventy-five feet and a depth of seven feet at low tide, or twelve feet at high tide, in the lowest stages of the river.

A contract was made with Mr. Augustus B. Wright, of Geneva, New York, on the 29th of January, 1868, for dredging a new channel in the river through Britt's Shoal and Gage's Shoal, between Hallowell and Augusta, Maine. This channel is to be seventy-five feet wide on its bottom, with a depth of six and a half feet at low tide in the lowest stage of the river. Under this contract twenty-two thousand and thirty-nine cubic yards have been excavated at Britt's Shoal, leaving about twenty-three thousand cubic yards additional to be done for its completion. The channel through Britt's Shoal will probably be completed before the 1st of October, 1869, and that through Gage's Shoal, more than half completed this season,* whereby the funds will become exhausted or nearly so. About thirty boulders (many of them weighing from three to five tons) have also been removed from the river at Shepard's Point, Hallowell and Britt's Shoals.

The appropriations already made for this work are as follows, viz:

By act of Congress approved June 23, 1866	$20,000 00
By act of Congress approved March 2, 1867	30,000 00
Total	50,000 00

The available balance of these appropriations on the 1st of July, 1868, was	$36,570 48
Amount expended during the fiscal year ending June 30, 1869, (including outstanding liabilities.)	33,420 73
Amount available July 1, 1869	3,149 75
Amount allotted to this work from the appropriation for the improvement of rivers and harbors for the fiscal year ending June 30, 1870, (approved April 10, 1869.)	15,000 00
Total amount available July 1, 1869	18,149 75

This amount will be sufficient to complete the channel through Britt's Shoal and partially through Gage's Shoal for a width of seventy-five feet. But in order to render this channel safely navigable for the large side-wheel steamers which run on the river below, it is very important, in my opinion, that its width be increased to not less than one hundred feet. To effect this and the dredging required at Hinkley's Shoal, (between Gardiner and Hallowell,) together with the completion of the channel through Gage's Shoal, will require an additional appropriation

* On the 11th of September, 1869, the channel through Britt's Shoal was nearly completed, and 5,590 cubic yards had to be excavated at Gage's Shoal.

of $22,500 which amount can be profitably expended upon the work during the fiscal year ending June 30, 1871.

The character of the bed of the river is such that it is not probable that any material change will occur to the detriment of its channel when once properly dredged.

The following information called for by the acts of Congress making appropriations for this work is supplied, viz: The works of improvement are located in the collection district of Bath, Maine.

Bath is the only port of entry in this collection district, and is situated on the right bank of Kennebec River, about thirty miles below Hallowell. Fort Popham is at the mouth of Kennebec River, about forty-five miles below Augusta, Seguin and Pond Island light-houses are near the mouth of the river. The United States Kenebec Arsenal is located at Augusta, Maine. The amount of revenue collected at Bath, (the port of entry,) for the fiscal year ending June 30, 1869, is $23,897 10.

From statements furnished the United States collector of customs at Bath, it appears that, during the year ending the 30th of June, 1869, the number of vessels of all classes, including steamboats, &c., to and from Gardiner, is estimated as follows, viz:

Number of arrivals at that port, (Gardiner)	650
Number of departures at that port, (Gardiner)	650
Total	1,300

That of this estimated number probably one quarter of them go up to Hallowell or Augusta to discharge and receive freight; and, if the depth of the river would admit of it, a much larger proportion would go above there than now go. The number of arrivals the ensuing year will be very much larger, owing to the increase of the ice business located between this place and Hallowell. This business alone this year will give employment to over three hundred vessels of large carrying capacity, to freight away what ice was stored in the houses at Farmingdale and Pittston, last winter, and quite a large portion of this increase of navigation has to go up the rive rwhere government improvements are now being made.

Hallowell and Augusta are largely engaged in various kinds of manufactures. At Augusta, lumber constitutes a large item, which has to be floated down in rafts to this city (Gardiner) to reach vessels that cannot go up the river for want of depth of water. This is but one item out of many which the manufacturers of the towns wish to export to market by water, during the navigable season of the year.

The work now going on by the government to improve the river channel to Hallowell and Augusta gives the people of these cities faith that they are soon to be opened to a full and complete water communication to the open sea, and hence they feel that the expenditures now being made will result in great benefit to all.

Accompanying this (see Appendix) is a letter from some of the leading practical men of Augusta, Maine, giving their views, also, as to the extent in which the commerce and navigation on this river would be benefited by the completion of the improvements as now proposed.

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 1, 1869.

AUGUSTA, *July* 19, 1869.

You ask for information as to the importance and value of the improvements of the navigation of the Kennebec river now in progress.

The undersigned, citizens of Augusta, respectfully bear testimony to the public value of this work, now in progress, and emphatically urge its speedy completion. The navigation of the Kennebec, from Gardiner to the head of tide-water at Augusta, vitally concerns two of the most valuable and prosperous counties of the State, containing about sixty towns and a population of nearly one hundred thousand. Augusta centralizes a valuable section of country, and has the elements of large future prosperity and wealth. It has an immense water-power, which has recently passed to the ownership of one of the leading manufacturing houses of the country. The amount of machinery now in use, or soon to be brought into operation, will require a large use of water-carriage to and from Portland, Boston, New York, Philadelphia, and other ports. The rapidly increasing use of coal for the various State and United States establishments located in Augusta, for the largely increasing manufactories and for domestic uses, demands water transportation. There are in operation extensive mills for the manufacture of lumber, which is shipped to different Atlantic ports.

The aggregate amount of this lumber is very large. The heavy and bulky agricultural products of the rich and extensive country above and adjacent to Augusta, find the cheapest transportation to the market by water.

Augusta, Hallowell and Gardiner have resources and advantages which cannot fail, at no distant day, to give them a population of fifty or sixty thousand.

The removal of the obstructions to the navigation of the river above Gardiner having progressed so far, the undersigned cannot doubt that the work will be continued to a final completion. Not to finish the work, which has already excited high hopes, would be a grave disappointment to a large number of people and prove detrimental to extensive and valuable business interests.

Yours, respectfully,

SAMUEL TITCOMB, *Mayor*.
JAMES W. NORTH, *Ex-Mayor*.
JOSEPH W. PATTERSON, *Ex-Mayor*.
J. P. WYMAN & SON.
C. & E. MILLIKEN.
D. WILLIAMS, *Ex-Mayor*.
A. & W. SPRAGUE, *Manufacturing Company*.
H. A. DE WITT, *Agent*.
WM. F. JOHNSON, *Ex-Mayor*.
JAS. W. BRADBURY, *Ex-U. S. Senator*.
J. A. BICKNELL, *Postmaster*.

See Long's Survey and Chart of Kennebec River, in Senate Document of United States, No. 114, twenty-fifth Congress, 2d session, 1837 and 1838.

JOHN L. STEVENS.

Hon. E. S. J. NEALLY,
Collector of Bath.

IV.—*Report on the improvement of the navigation of the Saint Croix river, above the "ledge," for the year ending June* 30, 1869, *by Brevet Brigadier General Geo. Thom, lieutenant colonel Corps of Engineers.*

By an act of Congress, approved March 2, 1867, the sum of $15,000 was appropriated for the improvement of this river: "*Provided*, The province of New Brunswick shall contribute and pay, to the proper disbursing officer, a like sum for said purpose; said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than one-half the sum actually expended for said purpose." As the co-operation of the province is yet to be obtained in this matter, operations have not been commenced.

The improvement of its navigation requires its channel to be deepened by the removal of slabs, edgings, and sawdust, which, for thirty years and more, have been accumulating in large quantities from the numerous saw-mills above and near Calais.

For an accurate estimate of the "amount that is required for the entire and permanent completion" of this improvement a careful survey will be necessary. An examination, made by me, showed that to open a channel one hundred feet wide, and ten feet deep at low water, would require the removal of not less than one hundred thousand cubic yards of slabs, edgings, and sawdust, which, at ninety cents per cubic yard,

would amount to	$90,000 00
Adding 10 per cent. for contingencies	9,000 00
Total	99,000 00
Deducting one-half, if paid by the province of New Brunswick	49,500 00
	49,500 00
Amount appropriated by act of Congress, approved March 2, 1867	15,000 00
	34,000 00
Additional amount required. (say)	35,000 00

Which amount could be profitably expended on the work during the fiscal year ending June 30, 1871.

The following information is supplied, in compliance with the requirements of the act of Congress making an appropriation for this work, viz:

The contemplated improvements of the "Saint Croix River, above the ledge," are within the collection district of Passamaquoddy, and near the custom-house in Calais.

There is no United States light-house now in use near this place, the nearest being in the vicinity of Eastport, Maine, about thirty miles below. There is no fort in the immediate vicinity, Fort Sullivan, also at Eastport, being the nearest.

The amount of duties collected at the custom-house in Calais for the fiscal year ending June 30, 1869, was $27,219 91.

The amount of commerce and navigation that would be benefited by these improvements consists of about one thousand vessels, (probably averaging about one hundred tons each,) which arrive at this port annually, being principally engaged in the coasting trade.

Hereto is appended a statement, by the deputy collector, showing the amount of "exports and imports at this port during the year ending

December 31, 1868, the number of arrivals and departures, and the number of vessels built."

GEO. THOM,
Lieut. Col. Corps of Engineers, Bvt. Brig. Gen. U. S. A.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, July 1, 1869.

Statement of exports and imports at the port of Calais during the year ending December 31, 1868, *the number of arrivals and departures, and number and tonnage of vessels built.*

DOMESTIC EXPORTS.

Pine lumber, feet	7,000,000
Spruce lumber, feet	47,000,000
Hemlock lumber, feet	18,000,000
Hardwood, feet	376,000
Hackmatack, feet	127,000
Laths	98,000,000
Pickets	6,666,000
Shingles	34,000,000
Spool stuff	536,000
Hackmatack knees	28,000
Cords bark	175
Cedar posts	42,000
Cedar sleepers	2,000
Broom handles	308,000
Bean poles	5,200
Clapboards	191,000
Barrels calcined plaster	26,921
Casks ground plaster	10,767
Ladders	55

FOREIGN EXPORTS.

Pine lumber, feet	1,564,000
Spruce, feet	2,441,000
Laths	150,000
Pickets	274,000
Shingles	3,320,000

IMPORTS.

Barrels flour	25,177
Bushels of corn	103,967
Barrels pork	836
Barrels beef	363
Tons rock plaster	6,686
Tons coal	1,000

ARRIVALS AND DEPARTURES.

Domestic arrivals	1,033
Foreign	56
Domestic clearances	1,022
Foreign	69

NUMBER AND TONNAGE OF VESSELS BUILT.

Barks	3
Brig	1
Schooners	6
Tons	3,499

Repaired on railways and dry-docks, 107 vessels.

B. M. FLINT,
Deputy Collector.

U 1.

UNITED STATES ENGINEER OFFICE,
Portland, Me., January 6, 1869.

GENERAL: I have the honor to acknowledge the receipt of letter from headquarters, dated the 31st ultimo, asking my attention to the matter of dredging a channel through the Middle Ground of this harbor, and instructing me to communicate my views as to the expediency of building a dredging machine, and prosecuting the work by hired labor, instead of by contract, and to furnish estimates for the same.

I have deferred making this report, in compliance with former instructions, as I have not been able to fully make up my mind as to the kind of machine which is best adapted to this work.

The depth to which it is proposed to dredge the bar is twenty feet below mean low water, or twenty-nine feet below ordinary high water; and the material to be excavated appears to be generally soft mud, more or less tenacious by its admixture with clay, not, however, difficult of excavation. At times the ocean-swells upon this bar create the greatest difficulty in the prosecution of the work. It was this difficulty which the contractors (Messrs. A. B. Cooley & Co., of Philadelphia) encountered, and they were not provided with sufficient and suitable machinery for overcoming it and for completing their contract in the required time, and with satisfactory advantage to themselves; and for this last reason they doubtless abandoned the work.

Of the various kinds of dredging machines now in use, the following are some to which I have directed my attention:

1. The new "plough and bucket" machine recently built at this place for Mr. Boschke, of Boston, for operations in that harbor. This machine is expensive, costing, with its requisite screws, more than twice as much as the machines and screws in ordinary use. Its capacity and advantage appear to be, and are believed to be, greatly superior to those of all other machines now in use in this country, and especially in deep water and in hard material. The capacity of this machine is claimed as six thousand cubic yards per day. The experiments thus far made with it, however, have furnished no positive information as to its great capacity and other superior advantages. I learn that in the course of the present month, it is to be fully tested in Boston Harbor.

2. The ordinary "endless chain and bucket" machine will not, in my opinion, answer the purpose in this harbor, except in very soft digging.

3. The single-dipper machine (known as Osgood's patent) is in general use, and is well adapted to digging in any material, especially in shallow water; while in deep water it loses proportionally its power and capacity for work.

4. The double-dipper machine (Morris & Cummings's patent) is much used in the harbors of New York, Buffalo, and elsewhere; and in soft material and deep water it has many advantages over most other machines in use, especially in the quantity of work it can perform, it being claimed for it that it can excavate from one thousand five hundred to two thousand cubic yards per day. I am not fully satisfied, however, as to its suitableness for the material to be dredged in this harbor. The cost of this machine and the expense of working it is about the same as that of the Osgood machine.

5. "Taggart's machine," also a double-dipper machine, is still different, though similar in its operations to Morris & Cummings's patent, and it appears to have some advantages over some others in deep water; but I know of none now in use in this section of the country, nor am I fully informed as to its merits. In my present state of uncertainty as to the advantages and merits of the Boschke machine, and the double-dipper machine, I submit the following estimates for operating with the Osgood machine, which is now in general use for work similar to that to be done in this harbor. Supposing the Osgood machine capable of excavating in this harbor two hundred cubic yards per day, and that eighty thousand cubic yards is the quantity to be excavated, four hundred actual days will be required for the work; or, adding twenty-five per cent. for Sundays, impracticable weather, and other unavoidable delays, say five hundred days, for a single machine. So that it will require more than two seasons to complete the work with but one machine, as it would generally be impracticable to work more than seven months in the year, (from the middle of May to the middle of December,) or, say, two hundred days.

1. Estimate for doing the work with one Osgood machine and hiring a steam-tug for towing off and dumping the material:

Cost of one machine, (with latest improvements)		$13,500 00
Cost of four scows, at $1,250 each		5,000 00
Repairs for two or more seasons, say.....................		1,500 00
		20,000 00
Wages of engineer and craneman, per day.......	$7 00	
Wages of five men, each $2 per day.............	10 00	
Coal for engine, say, per day	8 00	
Total, per day	25 00	
Expense of working machine 500 days..................		12,500 00
Towing and dumping 80,000 cubic yards, at 10 cents......		8,000 00
Total		40,500 00
Deduct probable amount that machine and scows would sell for on completion of work........................		10,500 00
Cost of excavating 80,000 cubic yards..................		30,000 00

or cost per cubic yard 37½ cents.

2. Estimate for two Osgood machines and hiring a tug as above:

Cost of two machines..................................	$27,000 00
Cost of six scows......................................	7,500 00
Repairs for one season, say............................	1,500 00
Total....................................	36,000 00

Expenses of working both machines 250 days, at $50 per day	$12,500 00
Towing and dumping 80,000 cubic yards, at 10 cents	8,000 00
	56,500 00
Deduct probable amount that the two machines and scows would sell for after one season's use, say	20,000 00
Actual cost for 80,000 cubic yards	36,500 00

or for one cubic yard 45.62 cents.

3. Estimate for two Osgood machines and one steam-tug purchased for the work:

Cost of two machines, six scows, and repairs as above	36,000 00
Cost of one steam-tug and repairs, say	8,000 00
Expense for working both machines 250 days, at $50 per day, as above	12,500 00
Expenses of working one tug 250 days, at $25 per day	6,250 00
	62,750 00
Deducting probable amount that the two machines, six scows, and tug would sell for after one season's use, say.	26,250 00
Cost of excavating 80,000 cubic yards	36,500 00

or for one cubic yard 45.62 cents.

4. Estimate for three Osgood machines and one steam tug, purchased:

Three machines	$40,500 00
Nine scows, at $1,250	11,250 00
One steam tug, say	8,000 00
Repairs on above, in one season	2,250 00
	62,000 00
Expense of working three machines $166\frac{2}{3}$ days, at $75 per day	12,500 00
Expense of running one tug $166\frac{2}{3}$ days, at $25 per day	4,166 66
	78,666 66
Deducting probable amount that the three machines, nine scows and tug would sell for after one season's use, say	38,666 66
Cost of excavating 80,000 cubic yards	40,000 00

or of one cubic yard 50 cents.

5. Estimate for dredging middle ground bar with one Boschke machine, six scows, and one tug, purchased for the work:

Cost of one single machine, say	$27,000 00
Cost of eight scows, at $1,500	12,000 00
Cost of one steam-tug	8,000 00
Repairs for one season, say	1,500 00
	48,500 00
Expense of working machine (supposing it capable of excavating 1,000 cubic yards per day) for 100 days, at $40 per day	4,000 00
Expense of tug 100 days, at $25 per day	2,500 00
Total	55,000 00

Deducting probable amount that the machine, scows, and tug would sell for at close of operations, say	$31,000 00
Cost of excavating 80,000 cubic yards	24,000 00

Cost of excavating one cubic yard, say 30 cents.

6. Estimate for dredging middle ground bar with one single Boschke machine and eight scows, purchased for the work, and one steam-tug hired for it.

Cost of machine	$27,000 00
Cost of eight scows, at $1,500 each	12,000 00
Repairs for one season	1,500 00
	40,500 00
Expense for operating machine (supposing it capable of excavating 1,000 cubic yards per day) for 100 days, at $40 per day	4,000 00
Hire of tug, running same and keeping it in repair 100 days, at $50	5,000 00
Total	49,500 00
Deducting probable amount that machine and scows would sell for at close of operations, say	25,500 00
Cost of excavating 80,000 cubic yards	24,000 00

or of one cubic yard 30 cents.

7. Estimate for doing the work with one Morris and Cummings machine, (double dipper,) six scows, and a steam-tug for towing and dumping the material—all purchased:

Cost of one machine, (complete)	$14,000 00
Cost of six scows, at $1,250 each	7,500 00
Cost of one steam-tug	8,000 00
Repairs on above, (one season)	1,500 00
	31,000 00
Expense of working machine (supposing it to excavate 500 cubic yards per day) for 200 days, at $25 per day	5,000 00
Expense of running tug for 200 days, at $25 per day	5,000 00
Total	41,000 00
Deduct probable amount that the machine, scows and tug would sell for, say	17,000 00
Cost of excavating 80,000 cubic yards	24,000 00

or of one cubic yard 30 cents.

From the foregoing estimates it appears:

1. That with a single Osgood machine and four scows purchased, and with hired tug, the work can be done for thirty-seven and one-half cents per cubic yard; but that more than two seasons will be required to complete the work.

2. That with two Osgood machines and six scows purchased, and a tug hired for towage and dumping, the work can be done for forty-five and one-half cents per cubic yard, and probably in one season.

3. That with two Osgood machines, six scows and one tug purchased,

the work can be done for forty-five and one-half cents per cubic yard, and probably in one season.

4. That with three Osgood machines, nine scows and one tug purchased, the work can be done for fifty cents per cubic yard, and in a part of one season.

5. That with one Boschke machine and eight scows purchased, and one steam-tug, (whether hired or purchased,) the work can be done in a part of a season at thirty cents per cubic yard, if the advantages and capacity of the machine be as great as above stated.

6. That with one double dipper machine, (Morris and Cummings patent,) six scows and one tug purchased, the work can be done for thirty cents per cubic yard, and in one season, if the advantages and capacity of the machine be as great as above stated.

These estimates are all based on the supposition that the machines, scows, and tugs will be sold on the close of this single work, in which event it would be advisable to employ either the Boschke or the double dipper machine, or else to purchase and employ two Osgood machines, with requisite scows and tug. But should it be deemed advisable to retain the machines, scows and tug, for other public works, in this department or elsewhere, the comparative cost of the work per cubic yard, will be as follows, viz:

1. With two Osgood machines, six scows and one tug, purchased and kept in order, at twenty-five cents per cubic yard, or $20,000 for the whole work.

2. With one Boschke machine, eight scows and one tug, purchased and kept in order, at ten cents per cubic yard, or $8,000 for the whole work.

3. With one double dipper machine, (Morris and Cummings patent,) six scows and one tug, purchased and kept in order, at fifteen cents per cubic yard, or $12,000 for the whole work.

The foregoing estimates for the Osgood machine are, in my opinion, reliable; but those for the Boschke machine, and for the Morris and Cummings patent, are based on the best information I have in regard to their capacity for work. Before recommending the adoption of either of these machines, I would desire to see them in operation in Boston, New York, and Buffalo, and be fully satisfied as to their respective advantages over the Osgood and other machines.

For the purpose of comparing the foregoing estimates for cost of work with the bids made for the work to be done by contract, I will add the following:

1. Lowest bid received from A. B. Cooley and Co., thirty-four cents per cubic yard.

2. Next lowest bid received from I. F. Hayden, of Buffalo, New York, for doing the work with a double dipper machine, at forty-four cents per cubic yard, or $35,200 for the whole work.

3. Lowest bid received from A. R. Wright, of Portland, Maine, on inviting proposals a second time, at sixty-five cents per cubic yard, or $52,000 for the whole work.

Mr. Hayden's price for doing the work is a reasonable one for a contract, and I think that he would still be willing to enter into a contract on those terms, if allowed to have one season for its execution. I would, however, recommend, in conclusion, that suitable machines, with requisite scows and tug, be provided by the United States, so that the dredging may be completed this season, without fail, and that the machinery be retained by the department for use in other engineering operations. This, in my opinion, is the only way in which the government can be

assured of the satisfactory execution of such work, either in the time or cost of its execution.

Very respectfully, your obedient servant,

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army,
Headquarters Corps of Engineers, Washington, D. C.

U 2.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, March 15, 1869.

GENERAL: I have the honor to report that, in compliance with your instructions, I have visited New York and Boston, for the purpose of examining into the merits of the dredging machine known as Morris & Cummings's patent, in operation in New York Harbor, and Boschke's patent, in Boston Harbor, with a view to ascertaining the most suitable and desirable machine for dredging in this harbor. The double-dipper machine (Morris & Cummings's patent) operates with very great facility and rapidity, and to any desired depth; the only question in my mind being as to the hardness and tenacity of the material which it is capable of excavating, as its power of penetration seems to depend, in a great measure, upon the weight of the dipper. The material which I saw it excavate in New York Harbor was a stiff though not very tenacious mixture of mud and clay, which nearly filled the dippers (of 1½ yard capacity) at the rate of about three times in every two minutes, at a depth of fifteen to twenty feet. An examination of the books of Messrs. Morris & Cummings, which I was kindly permitted to make, showed that the machine (with dippers of 1½ yard capacity) is capable of excavating, under favorable circumstances, fifteen hundred cubic yards per day; and generally it excavates about seven hundred to nine hundred cubic yards per day.

Messrs. Morris & Cummings claim for their machine that it can excavate stiff clay, or any other material as tenacious, as can be excavated with other machines, and so do others who have used these machines. Others, again, whose opinions are worthy of consideration, assert that these machines cannot work in stiff clay, or to advantage in any material into which the dippers will not penetrate by their own weight. My opinion is that they will work to better advantage in this harbor than any other machine, except, perhaps, Boschke's, or, possibly, Taggert's: first, because the material is not too stiff or tenacious for it; and, second, because it can operate with facility to any desired depth and with less danger of breakage and interruption by ocean swells, than other machines now in use. I will also here state that for removing slabs, edgings, and boulders, such as obstruct the Penobscot, Union, and St. Croix Rivers, in this State, for which appropriations have been made or asked for, there is no other machine (unless it may be Taggert's) which can accomplish the work so effectually, in my opinion, as Morris & Cummings's machine, with its skeleton dippers, which are especially designed for such work. In my report of January 6, I underestimated the cost of these machines. Morris & Cummings offer to make all the machinery complete for one machine, with latest improvements,

for the sum of $10,000; the hull, made here, would cost about $7,000, making the entire machine cost $17,000, or $3,000 more than my previous estimate. Messrs. Morris & Cummings will also require the United States to pay $10,000 for the privilege of using the patent in this State. This appears to be a large sum; but, on inquiry, is not more than is paid by private parties for its use elsewhere.

In Boston Harbor I also examined the working of Boschke's machine and was very favorably impressed with it. This machine consists of a large iron concave plow, which excavates the material, and buckets, on an endless chain, which empty the plow and carry off the material thus excavated. The machine built by Mr. Boschke for Boston Harbor is a double one with two plows and two sets of buckets or elevators, but the experiments made by him with it during the past winter satisfy him that for ordinary purposes a single elevator would be better.

This machine has a threefold advantage over most others: first, in the depth to which it can excavate without loss of power; second, in the very hard, stiff, and tenacious material which it can excavate; and, third, in the quantity of work it can do. I examined some of the material being excavated by it at a depth of thirty feet and found it to be a very stiff, compact clay. As to the quantity of work which it can do per day, I am not yet satisfied, nor do I think that Mr. Boschke is, as thus far he has been experimenting and improving on it. But for a single elevator he claims its capacity at not less than twenty-five hundred cubic yards per day, if I mistake not. I should not, however, estimate its average day's work at more than one thousand cubic yards.

At my request Mr. Boschke has furnished estimates and propositions for his machine, (a copy of which is furnished herewith,) from which it appears that for all the machinery and iron work complete for one single machine he will charge $20,000. The hull built here would cost about $8,000 making the machine, complete, cost $28,000, or $1,000 more than my estimate of January 6. For the privilege of using his patent in this State, Mr. Boschke asks the sum of $5,000.

In conclusion, I have to respectfully recommend that for removing the slabs, edgings, and boulders which obstruct the navigation of most of the rivers in this State, the Morris & Cummings machine, with skeleton dipper, should be used, and that the same machine, with dipper of 1½ cubic yard, be used for dredging in this harbor.

I do not feel fully satisfied at present as to Mr. Boschke's machine, although, after further experiments and proposed improvements, it may turn out to be the best machine for work in this and other harbors. But for removing slabs, edgings, and boulders, I know of none to compare with the Morris & Cummings patent.

Should it be decided to contract for the dredging in this harbor, it will not cost more than fifty-five cents per cubic yard, (a proposition made by Messrs. J. T. Hayden & Co., of Buffalo, New York,) or, say $50,000 for the whole work. But, in my opinion, the government can do this work at a cost not exceeding twenty-five cents per cubic yard, by building and operating its own machinery.

Taggert's machine, to which I have above referred, is a double-dipper machine, in which the dippers are opened and closed by handles, like a pair of scissors. It would appear to have some advantages over the Morris & Cummings patent in excavating hard material, if the leverage of the handles can be made sufficiently strong. But it has not been enough in use to prove these advantages.

The foregoing report would have been made earlier had I not been

prevented by sickness, with confinement to my bed and home for more than two weeks past.

I am, very respectfully, your obedient servant,

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army,
Headquarters Corps of Engineers, Washington, D. C.

BOSTON, *February* 24, 1869.

SIR: I have received estimates for building all machinery, elevators, and buckets for one of my patent dredges with one elevator.

I could furnish a double fourteen-inch cylinder engine with boiler and smoke-stack, donkey engine, two eight-inch cylinder engines and gears for hoisting elevator, the elevator with buckets, chain, all the shafting and gears to dive the buckets, elevator, hauling chain, hand-hoisting, &c., in fact, all the machinery and iron work required to set up in working order a complete machine for 'dredging, except the hull or vessel for the dredge, all this work warranted to be of the best material and workmanship, for the sum of twenty thousand dollars, and the use of the patent for the United States government for the State of Maine for the sum of five thousand dollars. Or the government may build the machine at their own expense, and pay the five thousand dollars for the use of the patent for said State.

I am ready to enter into any contract you may see fit to make, to purchase the machine and scows you may build under my patent right at the expiration of a reasonable time, for a sum we may agree upon, as I am going to build myself, in the course of a few years, several of the single elevator machines for work laid out in Boston Harbor.

Most respectfully,

A. BOSCHKE.

Gen. GEO. THOM, U. S. A.,
Portland, Maine.

APPENDIX V.

SAN FRANCISCO, CAL., *July* 31, 1869.

GENERAL: I have the honor to submit the following report of my official operations during the fiscal year ending June 30, 1869:

The operations have been conducted under the following appropriations:

Surveys of military defenses.

Purchase and repairs of instruments.

Removing obstructions in Willamette River.

Surveys and examinations on Pacific Coast.

Repair, preservation, extension, and completion of certain public works of river and harbor improvements.

River and harbor improvements for the year ending June 30, 1869, and for the year ending June 30, 1870.

The amount of the two last-mentioned appropriations, though having different names, are applied to the same improvements. In addition, I

am the engineer of the twelfth and thirteenth light-house districts and a member of the board of engineers for the Pacific Coast.

The operations under the above-named appropriations will be described in the order named.

SURVEY OF MILITARY DEFENSES.

Instructions having been received from the Chief of Engineers to cease disbursements under this appropriation, and to deposit the amount on hand to its credit with the assistant treasurer at this place, the amount on hand was so deposited and the account closed. The previous expenditures had been principally for collecting meteorological data, and a considerable amount had been collected which had not been reduced.

Upon representations made by me to the Chief of Engineers of the importance of the work being completed, I was given a small amount for that purpose. Nearly all the observers, however, agree to continue the observations, except those taken hourly, without compensation, and the work has continued with the expense of only about $150 per month. The results are valuable and increase in value as the series of observations become longer.

The following are the amounts received and expended during the fiscal year ending June 30, 1869:

Cash on hand July 1, 1869	$1,662 28
Deposited with the assistant treasurer at San Francisco, California, July 10, 1869	1,662 28
On hand July 10, 1869	....
Received during the year	$1,720 00
Expended during the year	1,690 60
On hand June 30, 1869	29 40

PURCHASE AND REPAIR OF INSTRUMENTS.

By the direction of the Chief of Engineers the amount on hand from this appropriation at the end of the first quarter of 1869 was deposited by me to its credit with the assistant treasurer at San Francisco, California, and the accounts under it thus closed.

The following are the amounts received and expended under it:

On hand July 1, 1868	$651 75
Expended during the year	105 08
Balance on hand March 31, 1869	546 67
Deposited with assistant treasurer at San Francisco, California, March 31, 1869	546 67
On hand April 1, 1869	....

REMOVING OBSTRUCTIONS TO NAVIGATION IN WILLAMETTE RIVER, OREGON.

This work has been under the immediate charge of my assistant, Lieutenant W. H. Heuer, United States Engineers.

The operations on this river during the past fiscal year have been

confined to dredging on Swan Island Bar, and the bar at the mouth of the Willamette River, as well as removing snags at each of the above-mentioned localities. Surveys of the Willamette Slough and of the mouth of the Willamette River were also made The Willamette River being sufficiently low during August, 1868, to commence dredging, a crew was hired and work resumed August 1, 1868, and continued until December 12, 1868, when work was suspended on account of high water. During this time 18,515 cubic yards of material were removed. The season had been very unfavorable for work; owing to the dense smoke from the woods which were on fire, we were unable to see more than fifty yards from the dredge. The Willamette is also so low during the summer that vessels of much draught must, in passing up and down, occupy the channel in which the dredging is done, and consequently every time a vessel passed we were compelled to stop work, haul out of position, allow them to pass, then get back into position and resume work, all of which caused much delay. While digging we also came into contact with numerous snags imbedded in the sand, whose presence would only be made known by the breaking of some part of the machinery of the dredger owing to the increased strain to which certain parts would be subjected. In December last, when dredging was temporarily suspended, we had cut a channel over Swan Island Bar which carried fifteen feet of water during low-water stages.

Steamers found no difficulty in keeping in the cut, which was well defined by buoys placed at its entrances and angles. The total length of channel cut since the commencement of the work in 1867 at this place has been 3,200 linear feet.

On the 25th of February, 1869, the Willamette River was again low enough to resume dredging. We therefore commenced excavating a channel at the mouth of the river, and continued dredging until May 8, 1869, when high water caused a suspension of operations. During this period of work we excavated 12,425 cubic yards of material. The channel cut was 841 feet in length by 100 feet in width by an average of 4 feet in depth, giving a channel carrying 17 feet of water during low-water stage.

There yet remains to be dredged at this place about 300 linear feet, averaging 2 feet in depth, which will probably be completed in August, at an estimated cost of $2,700.

Besides dredging, we removed 31 snags which were imbedded in the sand, the largest of which measured 30 feet in length by 9 feet in circumference. The quantity of material removed during the year was 30,940 cubic yards at a cost of $26,414 28, being an average of 85.4 cents per yard. This amount included the repairs of the dredger, the removal of snags, and the surveys of the Willamette Slough and River, which cost $4,861 77.

During the latter part of 1868 a survey of the Willamette Slough was made by F. H. West, (one of my assistants,) with a view of ascertaining its adaptability as a ship channel. The survey showed that the slough was not adapted for that purpose on account of its numerous rocky reefs. Maps of the slough, together with a map of the mouth of the river, were sent to the Engineer Department last February. A current chart was also prepared during the early part of 1869, showing the velocity and direction of the current during the winter freshet of 1868–'9 at the mouth of the river. This chart, also a map giving the latest survey of the mouth of the river, by Mr. F. H. West, accompany this report.

It was thought that the freshet in the river during January, 1869, would produce certain changes in the bed of the river at its mouth.

This actually occurred, and by comparing the last survey (accompanying this report) with those previously made in 1867 and 1868, it will be seen that the current washed out the sand so as to make a channel carrying 12 feet of water in places which previous surveys showed to be almost bare. The June rise of the Willamette River (occasioned by high water in the Columbia) seems to act injuriously to the channel at the mouth of the Willamette, causing a considerable deposit of sand which is only partially removed by the current of the Willamette, after the subsidence of the freshet. The accompanying current chart was made in January of 1869, when the Willamette was only about 10 feet higher than the ordinary low-water stage. This was the greatest height attained during the winter, and was 11 feet lower than the river was during the freshet of December, 1867. The current chart shows that the rate of the current during January, 1869, freshet averaged between two and a half and three miles per hour, which during a heavy freshet would probably be accelerated 33 per cent., the general direction of the current remaining the same.

In the June freshets the direction of the current is materially changed. The current then seems to come down the Columbia, passing between Percy's Island and Nigger Tom, as well as between Nigger Tom and Coon Islands, thence passing back into the Columbia through the slough B between Coon and Laurie's Islands. During this time the Columbia Slough also carries a considerable volume of water, the current of which passes in a northwesterly direction toward Gillingham Point, then separating, a portion passing through the slough B, the other portion takes a southwesterly direction, passing through the Willamette Slough back into the Columbia. The Columbia Slough was formerly used by steamboats in running to Vancouver, but it is now nearly blocked up.

I am directed to report on the following eleven points:

1. A survey of Swan Island Bar was made during the year, also of the bar at the mouth of the Willamette River and Willamette Slough. The plan adopted was to dredge Swan Island Bar so as to have 15 feet of water in the channel during the low-water season. Finished the work to that depth. At the mouth of the river we intended to dredge to 17 feet of water over the bar. That work is about three-quarters completed.

Items of expense during the year have been as follows:

Dredging at Swan Island Bar	$11,387 31
Dredging at mouth of Willamette	10,165 20
Repairs to dredger and surveys	4,861 77
Total expended during the year	26,414 28

2. It is estimated that the amount that will be required to complete the work at the mouth of the river will be $2,700. To deepen the channel at Swan Island bar to 18 feet of water will probably cost $31,200. It will also probably require a small annual appropriation to keep the channel open to 18 feet of water.

3. The amount that can profitably be expended upon the work during the next fiscal year is $26,500.

4. The collection district is Astoria, Oregon.

5. Portland, Oregon, is the nearest town.

6. The amount of revenue collected is unknown to this office.

7. The amount of commerce to be benefited by the completion of this work is very great. Steamers measuring two thousand tons leave San

Francisco weekly for Portland. A large number of sailing vessels also ply between these two ports.

8. No proposals were invited during the year, as the work is not being done by contract; but by the United States, by means of hired labor.

9 and 10. Hence no contracts were made.

11. The following are the amounts of money received and expended on account of the Willamette River work:

Cash on hand June 30, 1868	$8,914 99
Received during the year from appropriation for removing obstacles to navigation in Willamette River	9,500 00
For preservation, completion, &c., of rivers and harbors	9,000 00
Total on hand and received	27,414 99
Expended during the year	26,414 28
On hand June 30, 1869	1,000 71

The total amount of money appropriated which could be made available for improving the Willamette River was	$79,500 00
Total expended to June 30, 1869	52,576 26
Amount available to complete the work	26,923 74

SURVEYS AND EXAMINATIONS ON PACIFIC COAST.

During this fiscal year the only work done under this appropriation was a survey, by Lieutenant W. H. Heuer, United States Engineers, of portions of the Upper Columbia River, known as Homly Rapids and Rock Creek Rapids, with a view of ascertaining the size and position of dangerous sunken rocks on these rapids, with a view to their removal. A few experiments in blasting were made on a submerged rock at John Day Rapids, for the purpose of ascertaining the cost of removal of the numerous rocks in the various rapids of this river.

For maps and detail, see reports of my assistant, Lieutenant W. H. Heuer, United States Engineers, forwarded to Engineer Department, November 20, 1868.

Cash on hand June 30, 1868	$10,165 16
Received during the year	....
Expended during the year	4,781 91
On hand June 30, 1869	5,383 25

BLOSSOM ROCK, SAN FRANCISCO, CALIFORNIA.

During the year an allotment of $50,000 was made for the removal of this obstruction. Advertisements were made and proposals invited. Only one proposal was received, which was from Mr. Townsend, of Boston, Massachusetts, and that, proving unsatisfactory, was rejected. Subsequently two allotments, amounting in all to $25,000, were added, making the total amount available for the work $75,000. Mr. A. W. Von Schmidt, a civil engineer, submitted a plan for the removal of the rock, and offered to remove it to a depth of twenty-four feet, mean low water, for $75,000; no money being paid out by the government until

the satisfactory completion ot the work. Mr. Townsend also presented another proposition. These propositions were submitted to the Chief of Engineers for his decision. At the end of this fiscal year no decision had been made in the matter.

PACIFIC RAILROAD.

In October, 1868, the Secretary of the Interior appointed me one of the special commissioners to examine and report upon the Central Pacific railroad, and, upon the completion of our report, I was immediately appointed on another commission to examine the Central and Union Pacific railroads, from Sacramento to Omaha. On my arrival at Sacramento, on my way back to my station at San Francisco, I was met by an order to examine at once the Western Pacific railroad, between Sacramento and San José, California. These duties have occupied me during a large portion of the fiscal year, and during the remaining portion much time has been consumed in duty as engineer of the twelfth and thirteenth light-house districts, (Pacific coast.)

Respectfully submitted.

R. S. WILLIAMSON,
Bvt. Lieut. Col. U. S. A., Major of Engineers.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

Synopsis of contents of annual report for year ending June 30, 1869.

SURVEYS OF MILITARY DEFENSES.

The only disbursements under this appropriation have been about $150 per month.

The following amounts were received and expended during the fiscal year ending June 30, 1869:

On hand July 1, 1868	$1,662 28
Deposited with assistant treasurer at San Francisco, California, July 10, 1868	1,662 28
On hand July 10, 1868	....
Received during the year	1,720 00
Expended during the year	1,690 60
On hand June 30, 1869	29 40

PURCHASE AND REPAIRS OF INSTRUMENTS.

This account was closed, by order of the Chief of Engineers, at the end of the first quarter of 1869. It stood as follows:

On hand July 1, 1868	$651 75
Expended during the year	105 08
Balance on hand March 31, 1869	546 67

which was deposited with the assistant treasurer at San Francisco, California.

REMOVING OBSTRUCTIONS TO NAVIGATION IN WILLAMETTE RIVER.

During the year surveys were made of the Willamette Slough and of the mouth of the Willamette River. Dredging was done at Swan Island

Bar, and a channel 3,200 feet long, carrying 15 feet of water at the lowest stage of the river, was completed during this year. This year it is expected to nearly complete Swan Island Bar, excavated to 18 feet of water, at an estimated cost of $31,200. A channel at the mouth of the river was also excavated 841 feet long by 100 feet wide by 4 feet in depth. There yet remains to be dredged at this place about 200 linear feet, which will be completed this year, at an estimated cost of $2,700.

Total amount of appropriation for removing obstructions to navigation in Willamette River was	$45,000 00
From the appropriation for repairs, preservation, extension, and completion of public works on rivers and harbors, there has been allotted for the Willamette River	21,000 00
From appropriation for rivers and harbors for fiscal year ending June 30, 1869, and June 30, 1870, there has been allotted for the Willamette River	13,500 00
Total amount appropriated and allotted for this work	79,500 00
Total expended on work to June 30, 1869	52,576 26
Amount available to complete the work	26,923 74

SURVEYS AND EXAMINATIONS ON PACIFIC COAST.

Under this appropriation Homly and Rock Creek Rapids of the Upper Columbia River were surveyed, and some experimental blasts made on a submerged rock in John Day Rapids, with a view of estimating the cost of removal of dangerous rocks in the various rapids of this river.

Cash on hand June 30, 1868	$10,165 16
Received during the year	....
Expended during the year	4,781 91
On hand June 30, 1869	5,383 25
Total amount of this appropriation was	$50,000 00
Total amount expended to June 30, 1869, is	19,616 75
Unexpended balance of this appropriation is	30,383 25

BLOSSOM ROCK, SAN FRANCISCO HARBOR, CALIFORNIA.

No special appropriation has been made for the removal of this rock, but there has been allotted for its removal the following amounts:

From the appropriation for the repair, preservation, extension, and completion of public works on rivers and harbors	$50,000 00
From the appropriation for rivers and harbors for fiscal year ending June 30, 1869, and June 30, 1870, there has been allotted	25,000 00
Total amount allotted for the work	75,000 00

Mr. A. W. Von Schmidt has made an offer to remove Blossom Rock, to the depth of 24 feet below mean low water, for $75,000; which proposal was submitted to the Chief of Engineers for decision, but at the end of the fiscal year the matter was undecided.

V 1.

SAN FRANCISCO, CAL., *November* 7, 1868.

COLONEL: I have the honor to report that, in accordance with your instructions, I sailed from this place for Oregon on July 24, 1868, for the purpose of organizing parties for the continuance of work in the Willamette and Upper Columbia Rivers.

Parties were organized immediately after my arrival at Portland, Oregon, and the dredging apparatus was soon set at work at Swan Island Bar, in the Willamette River.

As the surveying schooner for the survey of the Upper Columbia River needed extensive repairs, those repairs were not completed until August 21. The succeeding day we sailed up the river and arrived at Homly Rapids on August 26, and began the survey next day at

HOMLY RAPIDS.

This rapid is in the Upper Columbia River, about one hundred and thirty miles above the Dalles, and about five miles below the mouth of Snake River. The nearest town is Wallula, (old Fort Walla-Walla,) Washington Territory, which is about four miles below the rapid. The river at Homly Rapids is three thousand three hundred feet wide, and contains numerous gravel bars. The current is rapid and varies with the stage of water in the river, being very much stronger in high than in low water. While we were at this rapid the rate of the current was six miles per hour, but during high-water season I am informed that it will average at least ten miles an hour; but during the lowest water the rate will probably not exceed five miles an hour. The soundings on the map indicate the depth of water at low-water stage, expressed in feet. The only part of the rapid where very careful soundings were made was between the two gravel bars, (see map,) as this was the only place in the rapid where there was much hope of being able to improve the navigation. The whole rapid was examined by me in a small boat, but with the exception of the place just mentioned, where the soundings show for themselves, the water was so shoal and rocks so plentiful that it was almost useless to devote much time to its survey; these shoals are indicated on the map by dotted lines. The whole of the river at this place is shoal, its bed is comparatively flat, covered with boulders, varying in size from an inch to several feet in diameter, and occasionally a portion of the bed rock (basalt) crops out and is visible under the water. The obstructions to be removed are ledges or portions of reefs of basaltic rock. Formerly there were large boulders in the river here, that interfered with steamboat navigation, but they were removed by private enterprise. The ledges which would require removal here are indicated on the map by dotted red lines, and measure one thousand one hundred and ninety-two cubic yards. One of the advantages that would result from improving this rapid would be that boats would be enabled to reach Lewiston, Idaho, on Snake River, a few weeks earlier in the season than at present. (See letter of J. C. Ainsworth, in Report of Chief

of Engineers for 1867, page 509.) According to that letter it would also enable boats to reach Priest's Rapids, in the Columbia; but, as there is no settlement at or near Priest's Rapids, I see no necessity of boats going there.

ROCK CREEK RAPIDS.

The next rapid surveyed is known as Rock Creek Rapids, situated in the Upper Columbia River, about forty-two miles above the Dalles. The shores on both sides of the river are rocky, and, within a mile of the river bank, the hills rise to a height of over a thousand feet. One thousand and eighty-two soundings were made in and near the channel of this rapid, and although many rocks were found, there were none that offered any serious obstacle to navigation. There are, therefore, no rocks recommended for removal in this rapid. The rapid is three-quarters of a mile in length, and in this distance has a fall of 8.34 feet; its current varies from five to ten miles an hour; during an ordinary stage of the river the current will not exceed six miles an hour, while immediately above and below the rapid, the current runs at the rate of one mile an hour.

BLASTING EXPERIMENTS.

Blasting experiments were made on a submerged rock in John Day Rapids, with a view of estimating the cost of removal of the various rocks in the river, but the results were unsatisfactory. A frame (see sketch of frame appended) was placed on "John Day Rock." It was thought advisable to put one or two drill holes in the rock, then insert some explosive compound, throw down as much rock as possible, by firing the blast, and thus make an estimate of the cost of removal of this rock. The drills used were of various shapes; some were plain, others curved like the letter S, while still others had a cross-section like this +, known as double bits or diamond drills; each of these drills was made so as to drill a three-inch hole, and were tried, but it was found that the plain bit would continually wedge in the hole; the curved bit (S) would chip off almost immediately after being inserted in the hole; therefore, the double bits or diamond drills were the only ones that could be used that promised any good results. With this bit we could drill a very round hole; it required three men to handle the drill, and the method adopted is called the churning process. The average depth of hole drilled per day, when work could actually be done, was twelve inches; each drill would require sharpening for every three inches of hole bored. The rock was so hard in places that the drill in striking against the rock would sometimes rebound three inches, and sound as though it were striking against an anvil. Considerable time was lost in preparing the drill-holes by not having a blacksmith on hand, but none could be obtained in that section of country; the drills had, therefore, to be sent to the Dalles (distant about thirty miles) to be dressed, and we were obliged to await their return. Eventually, after considerable trouble, we succeeded in getting the hole four feet deep, and placed in it a tin canister, containing four pounds of gunpowder, then endeavored to explode it by means of a Bickford fuse, but owing to some defect in the fuse, it failed to ignite the charge; the canister was jammed into the hole so tight that it could not be withdrawn. A cartridge was then prepared containing two pounds of giant powder and inserted in the hole (on top of the canister containing the ordinary powder) and exploded; the result was that 43.6 cubic feet of rock was removed.

As it would have taken many weeks more to have drilled another hole in the rock, we concluded to see what effect a surface blast would produce; a cartridge, containing five pounds of giant powder, was then placed under water, and under an overhanging shelf of the rock, in about six feet of water, and exploded, but without effect.

The experiments just made were of but little assistance in enabling me to make a fair estimate of the cost of removal of the rock. My impression is that the rocks can be removed by drilling holes in them, then inserting explosive material and firing the charge. I think, too, that that is the only practicable way of doing the work, but for such a hard rock a three-inch drill is too large; a drill one inch in diameter would be large enough, for with a one-inch drill a man ought to be able to drill two feet a day, whereas with a three-inch drill three men can only drill one foot per day; moreover, as the drill-holes will in no case be over seven feet in depth, a one-inch hole is better adapted to that depth than is a three-inch hole. I would also suggest that giant powder be used instead of ordinary blasting powder.

The following is the data obtained from the recent experiment on which to base estimates for the removal of the rock:

Expense of placing frame on rock	$50 00
Drilling holes, 3 men, 4 days each	40 00
Sharpening 15 drills, at $2	30 00
Powder and fuse	10 00
Total	130 00

Amount of rock removed; 43.6 cubic feet, cost per cubic yard, $81 25.

Owing to my inexperience in blasting, the above cost per cubic yard was very great, and should not be considered as anything like a fair estimate of the cost per cubic yard for removing the various rocks in the river. The subjoined estimate I consider more nearly correct.

		Gold.
Putting frame on rock and shifting same		$100 00
Cost of drilling each hole, labor	$10 00	
Sharpening drills for each hole	6 00	
Powder and fuse for each hole	2 00	
	18 00	
400 drill-holes, at $18 each		7,200 00
1 blacksmith, for 3 months, at $5 per day		450 00
1 assistant smith, for 3 months, at $3 per day		270 00
Hire of boats, for 3 months		900 00
100 drills, at $10 each		1,000 00
Removing frame from rock		50 00
Total in gold coin		9,970 00
Contingencies 10 per cent		997 00
Gold coin		10,967 00

$10,967 in gold = $15,667 14 currency, rating legal-tender notes at 70 cents; which would make the cost per cubic yard for removing the rock at John Day rapids = $18 09; to which should be added $10 per yard

for removing the debris, making a total of $28 09 per cubic yard. The various rocks in the rapids to be removed will measure 5,934 cubic yards, which at a cost of $28 09 per cubic yard would require $166,686 06 to be appropriated for this purpose.

Very respectfully, your obedient servant,

W. H. HEUER,
Lieutenant of Engineers.

Lieut. Col. R. S. WILLIAMSON, U. S. A.,
Major of Engineers.

Description of frame for submarine blasting.

Each of the four legs is a cast-iron gas pipe four inches in diameter, into the bottom of which a conical piece of iron is fitted to prevent the legs from slipping. In each of the four angles of the wood-work of the frame is an iron cylinder through which the legs can slide freely; each leg is firmly held, (when in position,) by means of a set screw attached to the cylinder. The diagonal braces are ordinary one-inch gas pipes and are fastened in iron bands, which slide up and down each leg and which can also be clamped by set screws; each leg has two of these bands, and each brace runs from the bottom band of one leg to the top band of the adjacent leg.

The frame weighs about twelve hundred pounds, is stable and durable, offers but little resistance to the current, and the platform from which the drilling is done can always be levelled irrespective of the shape of the rock on which it may be placed. It was used this year in John Day rapid of the Columbia river, where the rate of the current was seven miles an hour, and was found to work very well.

Respectfully submitted.

W. H. HEUER,
Lieutenant of Engineers.

Bvt. Lieut. Col. R. S. WILLIAMSON,
Major of Engineers.

SAN FRANCISCO, CAL., *November* 20, 1868.

GENERAL: I have the honor to forward herewith a report, with maps, of the survey made by Lieutenant Heuer, United States engineers, of Homly and Rock Creek rapids of the Upper Columbia River. These surveys complete the series contemplated in the act making appropriation for the survey and examination of that portion of the river. Some experimental blasts have also been made with a view to furnish data for an estimate for removing the obstructions. As the expense of such experiments is considerable, and as they are of no ultimate benefit unless an appropriation is made for actually removing the rocks, I did not consider it advisible to make further expenditures for that purpose. If the rocks are to be removed, the amount that can be profitably expended towards that object during the next fiscal year is estimated to be $50,000.

As the work of surveying the obstructions on the Upper Columbia River is completed, and as, after this month, no further expenditures under that appropriation are anticipated, I respectfully submit the

following as the amount already received and expended since the first of July last:

On hand July 1, 1868	$10,165 16
Received during the fiscal year	....
Total amount on hand and received	10,165 16
Expended and to be expended during the year	4,478 62
On hand December 1, 1868	5,686 54

Very respectfully, your obedient servant,

R. S. WILLIAMSON,
Bvt. Lieut. Col. U. S. A., Major of Engineers.

Gen. A. A. HUMPHREYS,
Chief of Engineers United States Army.

V 1*a*.

SAN FRANCISCO, *October* 16, 1869.

GENERAL: I have the honor to transmit herewith a report of Lieutenant W. H. Heuer, who has recently returned from the Willamette River, by my order, in order that he may be available to conduct the proposed survey at San Diego Harbor, very important duties, as engineer of lights on the coast, preventing my conducting it in person. The views expressed in Lieutenant Heuer's report are approved by me, and I respectfully request that the sum of $31,000 be appropriated for operations in the next fiscal year, which sum, it is supposed, will complete the work on Swan Island Bar, and keep open the one at the mouth of the river during that year.

I have the honor to be, very respectfully, your obedient servant,

R. S. WILLIAMSON,
Bvt. Lieut. Col. U. S. A., Maj. of Engineers.

Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

SAN FRANCISCO, CAL., *October* 16, 1869.

COLONEL: I have the honor to report that, in accordance with your instructions, I went to Portland, Oregon, on the steamer which sailed from here September 29, 1869. Having arrived at Portland I went on board the dredger which was busily engaged in dredging at the lower end of Swan Island Bar. Previous to recommencing work at this point this summer we had excavated a channel, which carried fifteen feet of water, entirely across the bar. In your annual report of operations of the Willamette River it was stated that "this year it is expected to nearly complete Swan Island Bar to eighteen feet of water, at an estimated cost of $31,200." This estimate, both as to time and cost, was made on the supposition that the cost of dredging, at a depth between fifteen and eighteen feet, would not vary very materially from what the previous dredging had cost; but, upon resuming work at Swan Island, (since the annual report referred to was submitted,) we find that

the operation of dredging is greatly retarded by the presence of innumerable snags, one of which (recently excavated) measured six feet in diameter by forty feet in length. The time occupied in removing one of these snags would be sufficient to excavate upwards of one thousand cubic yards of sand; it also causes an additional expense by incurring numerous breaks in the machinery of the dredger, which, were it not for the snags, would probably not occur. From the fact that these snags are at the lower end of Swan Island Bar, and embedded at this depth, and also from the fact that some of them have copper attached, (probably from some vessel having scraped over them years ago,) I am inclined to think that the lodging of these snags at this locality was the cause of the formation of Swan Island Bar. It may be that as we progress with the excavation further up the river these snags will disappear; it is probable that such will be the case, but should it be otherwise, it will be nearly impossible to estimate, with any degree of correctness, what it will cost to excavate Swan Island Bar to eighteen feet of water. It is certain, however, that unless these snags soon disappear the work cannot be completed during this fiscal year, and an additional appropriation will be required. At this date, there is available to prosecute the work $16,788 88, which will be sufficient to work for about five months longer, and allow us to attain a depth of seventeen feet of water over the bar, providing that portion of the bar between the references fifteen feet and seventeen feet be ordinary material, as sand and clay, but should this mass contain many snags, then the amount available will be insufficient to complete the work to that depth.

An annual appropriation is or will be required to keep the channel at the mouth of the Willamette River open. To open a channel, giving seventeen feet of water at the mouth, has cost the United States, in round numbers, $13,000. It is probable that this channel will partially refill during the summer freshet, but in all probability two months dredging will again open it. This will cost about $6,000. This amount annually appropriated would probably suffice to keep the channel at the mouth of the river open.

As it is proposed to dredge Swan Island Bar to eighteen feet of water, I think it would be advisable to request that an additional appropriation of $25,000 be asked for; this, together with one of $6,000 for the mouth of the river, would enable us to work until June 30, 1871, and would probably complete a channel of eighteen feet of water in the Willamette River from Portland, Oregon, to its mouth.

I have the honor to be, very respectfully, your obedient servant,

W. H. HEUER,
Lieut. of Engineers.

Bvt. Lieut. Col. R. S. WILLIAMSON, U. S. A.,
Major of Engineers.

V 2.

SAN FRANCISCO, *February* 13, 1869.

GENERAL: In compliance with orders from headquarters Corps of Engineers, dated at Washington, September 5, 1868, I proceeded to San Pedro or Wilmington, California, and made an examination of the harbor at that locality. Having been kindly furnished from the Coast Survey office at this place with a tracing of the Coast Survey chart, scale

$\frac{1}{10000}$, of the hydrography of the harbor and its approaches, a new survey was not necessary, as the chart, together with the information I obtained from personal examination of the harbor, has been sufficient to enable me to report fully on the wants of commerce at the locality, and prepare a project for such improvements as may be called for.

From an examination of the inclosed chart, it will be seen that the harbor or bay is formed by Rattlesnake Island and a sand bank to the south of it, from which they are separated from the main land by a narrow but deep bay or channel, the depth of water in which is, for two miles from its entrance, ten feet at low water in the shoalest place, and in many parts of it much deeper. Between this deep water and Wilmington, which is three miles from the entrance to the harbor, the water is more shallow, the chart showing in some places a depth of but three or four feet. At the entrance is a shoal or bar, the consequence of which is that steamships or other large vessels are compelled to lay off Deadman's Island, nearly a mile from the shore, and some four miles from Wilmington, and all passengers and freight in coming to this port must be transferred to lighters in order to pass over the bar. As soon as this is passed the water deepens to from ten to eighteen feet, and so continues to within a mile of Wilmington.

A railroad is in process of construction from the city of Los Angelos to Wilmington, and it is contemplated that it shall terminate on Rattlesnake Island, at the point above referred to as being about a mile below Wilmington.

The object of the proposed improvement is to so remove the shoal at the entrance that sea-going vessels can reach contemplated wharfs at the railroad depot.

An examination of the harbor shows that Rattleshake Island, though of low elevation, is not subject to overflow. At its southern extremity are a couple of sloughs with water from seven to twelve feet in depth, and then comes a broad flat, bare at low water, in length about three thousand feet to the bar at the entrance. The plan proposed for the improvement is to close these two sloughs, and to build up, from the southern end of Rattlesnake Island to the point off the bar, an artificial bank, so as to partially or totally confine the water of the bay (much of which now runs through the sloughs, and as the tide rises overflows the flat) to the channel between the islands and the main land.

It is supposed that when this is done the increased velocity given to the receding tide will partially remove the bar or shoal at the entrance. It is possible, though scarcely to be expected, that the deepening will be sufficient to admit into the bay vessels drawing eight or ten feet of water at low tide. If, however, the effect should prove not sufficient to give the required depth of water, then it will be necessary to continue the artificial bank as far as Deadman's Island, to the south of which the water is much deeper. The bank is to commence at A, (see line colored red on the chart,) and continue eighteen hundred feet to D, where the sand bank comes again above high water, forming an island about three hundred feet in width. From the southern end of this island, at E, the bank should be constructed in a right line, or perhaps better, in a curve parallel, to the channel, two thousand feet to the point B, opposite the bar. This will form the first section of the proposed work. The second section of the bank, should its construction be found necessary after the effect of the first section is proved insufficient, will terminate at Deadman's Island, as shown on the chart at C. A profile of the two sections is also inclosed.

These being the general features of the plan for this improvement, it

only remains to consider its details and the materials to be used. I presume it will be admitted without question, that the best material for this purpose to secure a permanent work is granite in large masses. It appears to me also that, as the success of the plan depends upon the scouring effect of the confined water of the bay, and as it is well known that such effect is produced almost entirely from half to low-water of the receding tide, and as the rise and fall of the tide does not exceed eight feet, I consider it will be sufficient to build the bank but six feet high above low water. Moreover, as the force of the waves will have been greatly diminished before the waves reach the shoal water on the line of the proposed improvement, I consider that it will be sufficient to construct the bank with a width at top of fourteen feet, and with a slope of one to one on both sides in the first section, where, for the most part, it is naturally bare at low water, while in the second section it should have a seaward slope of one vertical to four horizontal.

There is no granite or other first-class material for the proposed construction, in the vicinity of San Pedro or Wilmington, and, therefore, if such material is to be used it must be brought there in vessels. Granite of good quality and of easy access to the coast is found at a quarry some six miles south of Monterey, and I find that it can be delivered at a wharf, ready for shipment, for $2 per ton in coin. I also find that it will cost $4 50 per ton in coin to transport it from the wharf to the immediate vicinity of the place where it is to be deposited, and allowing $1 per ton more for placing the blocks in position, I have the following as an estimate of the cost of the proposed improvement in coin.

ESTIMATED COST OF FIRST SECTION FROM A TO B.

Cost of 36,673.5 tons of granite, at $2 per ton	$73,347 00
Transportation from quarry to San Pedro, at $4 50 per ton	165,020 75
Placing same in position, at $1 per ton	36,673 50
	275,051 25
Contingencies, ten per cent	27,505 12
Total cost of first section in coin	302,556 37

ESTIMATED COST OF SECOND SECTION FROM B TO C.

Cost of 63,958 tons of granite, at $2 per ton	$125,916 00
Transportation on same, at $4 50 per ton	283,311 00
Placing same in position, at $1 per ton	62,958 00
	472,185 00
Contingencies, ten per cent	47,218 50
Total cost of second section	519,403 50
Estimated total cost of both sections in coin	891,959 50

I consider that, by the use of large rough blocks of granite, the improvement can be made in a more durable manner, and with more certainty of success, than in any other way. It has been suggested, however, by others that the same end may be secured with less cost by a bank of materials of sufficient durability to last two or three years, because,

when the bank is once made, it will be strengthened and increased in size by the natural accumulation of materials brought against its seaward face by the waves. Mr. Ed. A. Flint, a civil engineer, now in charge of the Wilmington and Los Angelos railroad, has suggested such a plan, which I consider worthy of careful consideration. I have requested him to give me a written description of his project, which he has done, and I respectfully submit it in an appendix to this report, marked A. His estimate is $117,000 less than mine for the two sections. The cost of the first section in currency will be about $400,000 if granite is used, or $360,000 if Mr. Flint's plan is adopted. I respectfully suggest that should this construction be decided upon, a sufficient amount be first appropriated to complete the first section. Even should the result not fully secure the depth of water necessary to admit large sea-going vessels, it would certainly deepen the water to some extent, and so far prove a permanent benefit.

I inclose, in Appendix B, a letter from Mr. P. Banning, of Wilmington, giving statistical information of the resources of the country in its vicinity.

I have the honor to be, very respectfully, your obedient servant.

R. S. WILLIAMSON,
Bvt. Lieut. Col. U. S. A., Major of Engineers.

Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

WILMINGTON, LOS ANGELES COUNTY, CAL.,
January 2, 1869.

COLONEL: I have the honor to inform you, in reply to your esteemed favor of December 23, that there is at least one large steamer arrives at this port every week, and there are about ten sailing vessels irregularly employed in bringing merchandise and lumber to and from this place.

For the past year the freight has amounted to a little over fifty thousand tons, or about four thousand tons per month.

The number of passengers is about eight hundred per month.

The railroad from Wilmington to Los Angeles will be finished by July next, and it is proposed to continue it from there to San Bernardino.

The land in this and San Bernardino County is, as you are aware, the richest in the United States, and annually produces tens of thousands of tons of corn, barley, oats, and wheat. Over one million gallons of wine were manufactured last year, and double this amount will very soon be made annually.

The cost of lighterage from Wilmington to the anchorage (distance about six miles) is so great that farmers are now unable to ship their corn to a market.

Nearly all the troops and a portion of the supplies for Arizona are landed here.

In conclusion, permit me to assure you that there never can be any permanent prosperity in this portion of our State until we have a good harbor.

Very respectfully, your obedient servant,

PHINEAS BANNING.

Col. R. S. WILLIAMSON,
United States Engineer Corps, San Francisco, California.

WILMINGTON, *February* 3, 1869.

DEAR SIR: I have to thank you for your favor of January 16, and for the opportunity it affords me for further search for material to construct the breakwater at this port. I was unable when I last addressed you to enter into details, but am in hopes to partially supply the defisciency in this letter.

Starting at Rattlesnake Island and following the line of location sketched by General Alexander, we find the first five hundred feet bare at low tide, followed by two channels, separated by a ridge of sand about one hundred and fifty feet in length, also bare at low tide, which have a depth of water at low tide from seven and one-fourth to eleven and one-fourth feet. After leaving these channels we again come to a strip of land about three thousand feet in length of firmly packed sand, evidently formed by the sea wash from the east, and through its whole length laid bare at low water. From this point to Deadman's Island we have another stretch of three thousand feet, which has a depth of water varying from two to four feet at low water. These distances and depths of water are taken from the Coast Survey map of 1859. Since that time the sea appears to have altered very considerably the profile of that line just described, particularly along that portion represented on the Coast Survey map as being exposed at low water. At present writing a part of it is exposed even at high tide, showing that in ten years a very considerable quantity of sand and gravel has been washed in by the sea, and leading to the conclusion that if nature could be assisted by some description of breakwater the deposit would increase much faster on the east side than it has done, and in a few years not only cover the breakwater itself, but also form new land to such an extent that the decay of the breakwater would be no detriment to the value of the harbor.

Along a portion of the line above described, we have seen that the sea has deposited from six to eight feet of material in ten years, and assuming that, with the assistance of a breakwater, at least an equal amount of deposit could be expected in the next ten years, it would then only be necessary to raise a structure of such material as would exist for that length of time. I have been unable as yet to find any quarry where suitable stone can be found. A sufficient quantity of boulders, washed round by the sea, are easily obtained and could be used in timber cribs. Owing to their shape it would be impossible to use them without confining them in some way. They are in a very convenient position for the work, being located on the shore beyond the present San Pedro landing at the south, and the size of the stone ranges from five to fifty pounds. It would be necessary, however, in order to move them to advantage, to build about two miles of railroad, and a wharf, about eight hundred feet in length, out to such depth of water as would enable a tug-boat with lighters to come alongside. Probably the best timber for cribs would be the California red wood, impregnated with coal tar, by placing the wood in an air-tight cylinder, exhausting the air and allowing the hot liquid to flow in and fill the vacuum. This would secure at least ten years' life for the wood, from all destructive agencies except the *Teredo navalis*, and this little creature would have but little chance to attack it after the first year, as it would probably be covered above the level of low water by that time.

In the following sketch for a crib breakwater, I have allowed very liberally for settling of cribs into the sand, probably much more than would actually take place, but it has been my endeavor to err on the safe side. At the two channels, south of Rattlesnake Island, I have

assumed the average height of crib-work at eighteen feet. On four thousand feet of the distance, which is exposed at low water, nine feet will be amply sufficient. The balance of the distance to Deadman's Island is taken at an average of fifteen feet; will allow the wall to settle on an average five feet into the sand. The cribs themselves are estimated at thirteen feet square on bottom, and six feet in height, made of twelve by twelve-inch timber and halved into each other and bolted. This shape of crib is arbitrary and it is not improbable that a better shape could be used. I was governed in the size by a desire to have blocks weighing about thirty tons, and also to have a size convenient to fill from lighters, while to add to the strength of the wall they could be laid to break joints.

To guide the cribs in settling and to assist in passing a railroad, I estimated for a double row of piles on either side, with longitudinal stringers and cross-ties, all of twelve by twelve-inch timber, (Oregon pine,) the piles, of course round, at least fourteen inches at butt without bark, thirty feet in length, and protected with coal tar.

You may consider, upon examination of the following estimate, that on four thousand feet of the distance, where I have allowed for crib-work nine feet high, that I have been more liberal than necessary, and I have no doubt that a careful examination might reduce this considerably; yet I have concluded to submit these figures for your consideration, with the hope they will be sufficiently large to accomplish the desired object.

	Board measure.
400 feet crib-work, 18 feet deep, 100 cribs, 13×13×6 =	600,000
4,000 feet crib-work, 9 feet deep, 500 cribs, 13×13×6 =	3,000,000
2,600 feet crib-work, 15 feet deep, 500 cribs, 13×13×6 =	3,000,000
	6,600,000
At $50 per M	$363,000 00
8,000 piles, 30 feet long, at $15	$120,000 00
Capping and tie beams, 400,000, at $50	20,000 00
Bolts, 20 tons	4,000 00
30,000 tons of stone, at $4	120,000 00
	627,000 00

Before closing I would state that I have recently been informed that there exists, some ten miles beyond Los Angeles, a hill containing cement with hydraulic properties, and that the fountain at the Lafayette Hotel in Los Angeles was laid with this material. General Banning has already sent for some of this material to experiment upon. If it should prove to be true that hydraulic lime can be obtained, it would be a comparatively easy matter, upon the completion of the railroad this summer, to place this cement on the spot we should need it, at quite reasonable figures; and with the sand, gravel, and such stone as could be obtained, we should be able to dispense with lumber altogether and build such blocks of stone as desired.

I remain, your obedient servant,

EDWARD A. FLINT.

Col. R. S. WILLIAMSON,
United States Engineers, San Francisco.

V 3.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., July 3, 1869.

SIR: I beg leave to submit for your approval a contract proposed to be entered into by Brevet Lieutenant Colonel R. S. Williamson, Corps of Engineers, and A. W. Von Schmidt, civil engineer, for the removal of Blossom Rock, in the harbor of San Francisco.

Blossom Rock is a hard, sandstone rock, only five feet under water at low tide, lying in an exposed situation, about midway between Alcatraz and Yerba Buena Islands. At a depth of twenty-four feet at mean low tide, its length is about one hundred and ninety feet and width one hundred feet.

Experiments in blasting this rock were made in the winter of 1866–'67 by Lieutenant Heuer, Corps of Engineers, under the direction of Lieutenant Colonel Williamson, from which it was estimated that the probable cost of its removal would be about $60,000.

As these experiments attracted attention at the time, Brevet Brigadier General Alexander, Corps of Engineers, and Mr. A. W. Von Schmidt, a well known civil engineer of San Francisco, who has had experience in works of this character, voluntarily submitted plans for the removal of this rock.

General Alexander proposed to excavate, by the aid of a coffer dam, radial chambers in the rock, for the reception of heavy charges of powder, to be simultaneously exploded, the fragments afterward to be removed by dredging or other means. His estimate was $41,000, for blasting alone, as, from the uncertainty of the effects of the blast, no estimate could be formed of the cost of removing the debris.

Mr. Von Schmidt's plan was to excavate the rock in such a way as to leave but a shell upon the surface, which, when the explosion took place, would fall into the excavation and leave a uniform depth over the spot. His estimate was $75,000, for the entire removal of the rock and its debris to a depth of twenty-four feet.

Believing other persons might be found willing to undertake this with other and perhaps better plans, proposals were invited by advertisement in both eastern and western newspapers for the space of two months, which resulted in but two bids, one from the above-mentioned Mr. Von Schmidt, and another from Mr. Geo. W. Townsend, the contractor who removed Tower Rock in Boston harbor.

Mr. Townsend proposes to furnish all materials, machinery and labor, and to do the work at $125 per day, without specifying the number of days required, or insuring any certain amount of work to be done in any specified time.

Mr. Von Schmidt, without confining himself to any particular plan of operations, offers to remove the rock to a uniform depth of twenty-four feet in eighteen months, for the sum of $75,000, and to receive no compensation whatever until after "and upon the full and complete performance" of his contract.

Taking into consideration the great uncertainty of work of this nature, Mr. Von Schmidt's proposition appears the more advantageous of the two, as the government runs no risk from his failure, while should he not succeed, we may profit by his experience in forming future plans for accomplishing the object in view.

I respectfully recommend that his contract with Lieutenant Colonel

Williamson be approved. If approved, an additional allotment of $5,000 will be required for the work, which I recommend.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

Hon. JOHN A. RAWLINS,
Secretary of War.

Approved by the Secretary of War, July 7, 1869.

ED. SCHRIVER,
Inspector General.

HEADQUARTERS CORPS OF ENGINEERS,
Washington, D. C., February 24, 1869.

GENERAL: In compliance with the resolution of the House of Representatives of the 28th of January last, I herewith transmit a plan and estimate for the improvement of Rondout Harbor New York, prepared by Brevet Major General John Newton, lieutenant colonel of engineers. I concur in the recommendations made in this report.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General of Engineers, Commanding.

Maj. Gen. J. M. SCHOFIELD,
Secretary of War.

SAN FRANCISCO, CAL., *October* 3, 1868.

COLONEL: Since the passage of an appropriation by Congress for the removal of "Blossom Rock" in this harbor, I have been thinking from time to time as to the most practicable way of getting rid of that rock, and, having arrived at a conclusion on the subject which is satisfactory to my own mind, I venture, inasmuch as it differs from the processes usually followed, to communicate it to you for your information.

I understand that you are charged with the execution of this work, but when I assure you that I have no desire to interfere in any manner with your duties, I feel confident that this assurance, taken in connection with our personal relations, will relieve me, in your mind, from any other wish in the matter than to see this work prosecuted to completion in the cheapest and speediest manner. I send you, therefore, without apology, a sketch which will explain my ideas on the subject, together with a description of the proposed operations.

Having had considerable experience in such matters, particularly in building a coffer dam around the site of Fort Richmond, Staten Island, when that fort was commenced, I will add that I have no doubt of the entire practicability of putting the proposed dam on "Blossom Rock" in the manner proposed, nor have I any doubt but that it may easily be made practically water-tight.

It then becomes a question of sinking a shaft and tunneling under the rock. There will be no trouble in this operation if the rock itself will keep out the water.

On this point it is impossible to pronounce judgment before investigation. If the rock is like that at Lime Point, or at Angel Island, or at Alcatraz, or Yerba Buena, or Point San José, the leakage into the tunnels will be small and but little pumping will be required.

There can be no doubt, if these tunnels can be made without lining, that this will be the cheapest and most expeditious way of removing the rock. Should it be found, however, (of which I have little fear,) that the tunnels cannot be made as I have designed them, I think you would find such a dam as that proposed of great assistance, whatever plan of operations you might then be forced to adopt. It would give you a fixed point on the rock, which will be the first requisite in enabling holes to be drilled into the rock. If you undertake to drill for blasting, I think you will find a fixed point for your drills absolutely necessary.

Again, the coffer dam would enable you to build a barrack and blacksmiths' shop upon it, where the workmen could live and be always on hand to take advantage of good weather and favorable tides; saving thereby to a great extent the expense of vessels for the transportation of workmen and tools.

I have not attempted to make the sketch, or the description, in such minute detail as will be necessary before commencing such operations.

All I proposed to do was to present a plan in outline, to show the practicability of such an undertaking, with such hints as would serve as an indication of the course to be followed.

I do not propose for you to adopt the plan I have suggested, on my responsibility. In an undertaking of this sort, where there is a possibility of failure, it is proper that the mode of proceeding should receive full investigation, and then the engineer department should assume the responsibility for whatever plan may be finally adopted.

While, therefore, I do not hesitate to say that if I were charged with the removal of "Blossom Rock," I would urge the department to sanction the plan I have prepared for that purpose, all I can ask of you is, that you will forward this plan, with the written description, and a copy of this letter, to the Chief of Engineers for his information.

Very respectfully, your obedient servant,

B. L. ALEXANDER,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

Col. R. S. WILLIAMSON,
Corps of Engineers U. S. A., San Francisco, Cal.

BLOSSOM ROCK.

This is a sunken rock in the harbor of San Francisco, with about five feet of water upon it at low water. It is situated a little over three-quarters of a mile from the city front, and is in the track of vessels approaching the city from the ocean, or in going to sea, and is directly in the way of vessels running to and from the Sacramento and San Joaquin Rivers. The length of the rock above the level, which would give twenty-four feet of water over it at low water, is about 180 feet. Its breadth above this level is about one hundred feet.

The removal of so large a rock by surface blasting will, I fear, be a long as well as an expensive undertaking. After a good deal of reflection on the subject, I have arrived at the conclusion that it may be done in a single season, and at greatly reduced cost, by undermining the rock, making a number of powder chambers under it, and blowing the whole rock to pieces at a single operation. To do this, I propose to inclose a small surface of the rock by a water-tight coffer dam. In this space to sink a rectangular shaft, about four feet by nine feet, which is the size

I have seen in coal mines. From the bottom of this shaft to run tunnels and make powder chambers in such positions, that when exploded, the whole rock down to the level of twenty-four feet below the level of low water will be lifted into the air and shivered to pieces.

DESCRIPTION OF THE PROPOSED OPERATIONS.

I propose in the first place to blast off a small portion of the top of the rock, by what we call surface blasting, down to about the reference of ten feet, or ten feet below low water. This is for the purpose of furnishing a comparatively level surface upon which to build a coffer dam. This blasting operation will consist in lowering down charges of from one hundred to three hundred pounds of gunpowder to the surface of the rock, over the part to be removed, in water-tight vessels, and exploding them by means of Beardslee's magneto-electric machine, and afterward removing the shattered portions of the rock by men in armor. It will not be necessary to try to get a smooth surface. All that is necessary is to get a surface upon which the coffer dam will stand. (See Figs. 1, 2, and 3.) This operation will be a little tedious, but will not be very expensive, as the quantity of rock to be removed is small and but few men will be employed in it. There is no doubt of its entire practicability. In fact it is believed that the whole rock to any required depth might be removed by this process, the only objection being the great cost. It is probable that nitro-glycerine or giant powder, owing to their powerful local effects in shattering, would prove a more efficient agent for this surface blasting than gunpowder. This being done, I propose to frame a strong coffer dam of twelve-inch square timber, as shown in Figs. 4 and 5. This may be built on shore and made water-tight. It should be built up so as to be thirteen feet high before launching. It will then, if built of Oregon pine, draw about ten feet of water, and may be easily towed out and anchored over the spot where it is to be placed. It will then just ground on the rock at low water, and by the aid of ballast, say bags of sand placed upon platforms, or otherwise fastened to the dam, be prevented from floating as the tide rises. If it does not ground in exactly the right place at the first trial, the bags of sand may be removed, when it will float again, and its position may then be altered at the next low water. A sufficient number of mooring buoys will have to be placed around the rock during this operation, to enable the coffer dam to be drawn exactly into the required position. When it has been finally placed it may be loaded with sand-bags or other ballast spiked to the sides, or piled in temporary platforms so arranged as to be easily removed afterward, and the construction completed by carrying it up to the required height, say to the reference ten feet or five feet above high water. Having got it built, I would next plank it over and load it down securely with ballast, taking care to have man-holes in each of its ten compartments. I would then put down sheeting piles both outside and inside of the dam. I have supposed them to be three inches thick and rather narrow, say nine inches wide. It is not supposed that these sheet piles can be driven into the rock, but by cutting the lower ends to a feather edge they may be driven down until the lower ends crush into the crevices of the rock, stopping to a great extent the flow of water under the dam. I have supposed that there are two rows of these sheeting piles both outside and inside. The second row may or may not be necessary. These piles should be bored beforehand to receive several six-inch spikes, and after each pile has been securely

placed against the dam, and against the sheet pile last driven, a man in armor should go down and drive the spikes so as to hold it in position. This being completed, the next operation will be to fill up the inside of the dam so as to make it water-tight. I have supposed that we will use concrete placed in bags to fill it up to the low-water level, though it is altogether likely some cheaper material may be found to answer. If bags of concrete are used, they should be about half filled, and of such a size as not to weigh more than fifty or seventy-five pounds when immersed in the water. When ready to be put in place, a man in armor would go down into one of the compartments of the dam and place them in the crevices of the rock, taking care to fill up solidly the spaces under the timbers, particularly below the timbers which connect the inside with the outside wall of the dam, under which there would otherwise be leakage. To give room for this operation it might be better to frame these lower timbers, say six inches above the bottom of the outer and inner timbers, though they are not so represented in the drawing. Having these spaces under the timbers securely filled, all the men down there would have to do would be to kick the concrete bags into place and walk over them as they were lowered down until the compartment was filled. The concrete, if made of good cement, would soon harden and the cement would come through the bags so as to unite them and make a water-tight mass. I would recommend that this concrete be placed in layers of about two feet in thickness, carrying it up a layer of about that thickness each day. The concrete being all in position, the upper portion of the dam is to be filled up with clay or some other water-tight material. The middle compartment of the dam is to be kept open, and it is supposed when the dam has been finished in the manner described, that this compartment will be practically water-tight. All that is necessary therefore to reach the surface of the rock within this space, will be to pump the water out of it. If the dam is found not to be entirely water-tight, it may easily be made so by calking between the inside sheeting piles, and between their lower ends and the surface of the rock.

We are now prepared to sink a shaft into the rock. I have supposed it to be four feet by nine feet in the clear, leaving a ledge of twelve inches between its edges and the face of the sheeting piles on the inside. I suppose that this shaft will be sunk so that its bottom will be in the reference of thirty-six feet, and at this level small tunnels will be run under the rock, as shown in plan in Fig. 1, and in section in Figs. 2 and 3. At the ends of, and in these tunnels, fifty-five separate chambers for powder will be placed, as shown in plan, and connected by insulated wires with the battery or machine for exploding them. Water will then be admitted through the sluice for tamping, and the whole space filled, pumping water into the middle compartment until it is filled to the top or reference of ten feet. The mines may be fired simultaneously by the use of about three of Beardslee's machines. In consequence of the great depth of the charges, I would recommend that the explosion take place at low water. I propose so to adjust the charges in the chambers, that all the rock above the reference of twenty-four feet will be blown up, shattered, and broken to pieces. Much of it will fall back again, but the currents will rapidly remove a great part of it, and the remainder may then be scraped off into deep water, sending down men in armor when necessary to fasten to pieces that may prove too heavy to be scraped off. The quantity of powder that would be necessary to lift the rock and the water above the mines would be about thirteen thousand pounds,

but as it will be desirable not only to lift the rock, but to break it up into small pieces, and blow it away as much as possible, I would recommend that about double this quantity of powder be used, say twenty-six thousand pounds; the quantity of powder in each chamber being proportioned to the weight it will have to lift, or to the work it will have to do.

ESTIMATED COST.

Blasting off and removing top of rock to receive the coffer-dam, 150 cubic yards, at $40	$6,000 00
Building coffer-dam, 61,500 feet of timber, at $40 per M, including workmanship and materials	2,460 00
Cost of placing frame-work in position, say	1,000 00
Cost of sheeting piles, 20,300 feet, board measure, at $40, including spikes	812 00
Cost of placing the same, say $1 per piece	452 00
Cost of concrete, 200 cubic yards, at $15	3,000 00
Cost of clay filling, 200 cubic yards, at $3	600 00
Cost of planking over the dam, joists and covering, 5,000 feet, at $40 per M	200 00
Cost of shaft with enlargement at bottom, 40 cubic yards, at $10	400 00
Cost of tunnels and powder chambers, 778 running feet, at $15	11,670 00
Cost of powder, say 26,000 pounds, at 10 cents	2,600 00
Cost of 55 packages, and placing the same, at $20	1,100 00
Cost of engine for pumping and hoisting	2,000 00
Cost of pump and fixtures	1,000 00
Cost of derrick and rigging	1,000 00
Add for contingencies, including barrack and smith's shop over the dam, use of boats, superintendence and unforeseen expenses, say 20 per cent	6,838 00
Total, (in coin)	41,132 00

I do not make any estimate of the cost of removing the broken rock after it has been blown to pieces, because it is impossible beforehand to tell what operations will be necessary in order to accomplish this object If the rock is anything like that at Lime Point, and if it is shattered like the blasts there have shattered that rock, the currents in the course of a year would remove the greater portion of it. But if it should be a stronger rock, and come out in larger masses, it would have to be removed by mechanical operations and at considerable cost, which, however, would be far less by having the whole rock broken to pieces, down to the required depth, than would be the case if the rock had to be blown up by piece-meal, involving a removal of the debris after each successive series of blasts.

B. L. ALEXANDER,
Lieut. Col. Engineers, Bvt. Brig. Gen. U. S. A.

SAN FRANCISCO, *November* 20, 1868.

SIR: I have the honor herewith to submit to you a plan and descriptive specifications for the removal of Blossom Rock, in the Bay of San Francisco, California.

Blossom Rock, so called, is a sunken rock so well known that I consider a description of its locality unnecessary for these specifications, and shall, therefore, proceed with explaining my plan for removing the same; reference being had to the annexed plan, in which—

Plan A represents the mode and manner of constructing the necessary machinery for working out the interior of the rock.

No. 1 represents the longitudinal section through *c d*.

No. 2 represents transverse sections of rock through K L as represented on the plat of survey made by Edward Cordell, assistant United States Coast Survey, February, 1867.

The first object in view is a thorough removal of the rock, so that vessels drawing twenty-four feet of water will be able to pass over the same at low tide. To accomplish this, the mere blasting and breaking up of the rock would not, in my opinion, accomplish the desired object, as the rock in broken masses would still form an obstruction to the navigation of the harbor. I have, therefore, matured a plan by which the entire rock itself shall be excavated in chambers, as shown by the accompanying plan marked A, Nos. 1 and 2.

The rock taken out of the interior copartments will be removed through a shaft and discharged into deep water alongside the rock; and when the whole inside of the rock shall have been removed I propose, finally, to blast the crust over the chamber, and drop the same to the bottom of the excavation.

To accomplish this, the following mechanical arrangements will be necessary. I make my lodgment on the highest point of the rock, which is nearly or quite level at this point, being five feet under low-water line, and having a sufficient area for the works necessary to be constructed. I moor a scow for working purposes in the position required; I then place a boiler-iron case, nine feet in diameter and thirteen feet high, with flanges on the lower end, on the top of the rock. This flange has a canvas apron three feet wide running entirely around it, and lying on the rock. I then place a lot of sand bags on the top of the canvas apron, and around the case; and to secure the case I use one and a half inch round iron rods, the ends of which are firmly secured into the rock by "Lewis holes," turnbuckles are also placed on each rod for the purpose of tightening them up from all sides. After this is done I pump out what water there is in this case, and make an excavation into the rock downwards, for the purpose of erecting the main case, which is of boiler-iron, six feet in diameter, and seventeen feet in height. This is set within the outside casing, and also firmly set into the rock and secured with anchor bolts, in the same manner as with the first case. After this is done I fill all cracks between the casing and the rock with Roman cement, excluding the water from the interior iron casing. When it is found that the leakage has been thoroughly stopped, and the platform erected as represented in the plan, I commence sinking a shaft down through and into the main body of the rock to the depth required; at which point I place a pump for removing such water as may be encountered in carrying on the work. From the bottom of the shaft I commence tunneling the rock in all directions. As fast as the rock is worked it is brought to the center shaft through the different tunnels and placed in a tub, when it is hoisted by steam and discharged alongside the rock into deep water by means of the swinging derrick.

The rock that will remain between the excavation and the water will be about six feet in thickness, supported by pillars four feet square and ten feet apart from center to center. It is proposed to remove most of these pillars when the rock shall have been tunnelled and to set up in

their place wooden supports as often as may be required to sustain the weight over head. When this entire mass of rock shall have been excavated the works will be in readiness to receive the several packages of powder, in such quantities as shall be thought necessary, the wires being laid to the several torpedoes and connecting with a magnetic battery placed in a vessel near by. The chamber is to be filled with water and the torpedoes fired by the battery simultaneously; when it is supposed that the entire shell of rock will be broken into small pieces and be precipitated to the bottom, the timber supports floating out, and the work completed in all its details.

All of which is most respectfully submitted,

A. W. VON SCHMIDT,
Civil Engineer.

Lieut. Col. W. R. WILLIAMSON, U. S. A.,
Major of Engineers.

SAN FRANCISCO, *November* 20, 1868.

SIR: I have the honor herewith to submit to you a plan for the removal of Blossom Rock, together with a description of doing the work.

I will remove the said rock, in accordance with the plan as proposed by me, in the space of eighteen months from the time of signing the contract, for the sum of seventy-five thousand dollars, currency of the United States, giving such bonds as shall be required for the faithful performance of the work.

Yours, respectfully,

A. W. VON. SCHMIDT.

Lieut. Col. W. R. WILLIAMSON, U. S. A.,
Major of Engineers.

SAN FRANCISCO, *November* 23, 1868.

GENERAL: In my letter to you of September 22, I had the honor to express the opinion that the only way of removing Blossom Rock was by drilling deep holes in it, in which to place explosive materials. The recent experiments on John Day Rock, in the Upper Columbia, showed the practicability of that method, and the frame devised by Mr. Heuer was successfully used; nevertheless, the method of drilling was tedious and expensive, and, as stated in that letter, the rock should be removed to more than eighteen feet from low water mark.

The recent duty to which I have been assigned on the Pacific railroad, and the usual heavy rains in December and January, have decided me to defer the commencement of operations for two or three months; and recently other methods of removing the rock have been suggested, which I consider worthy of serious attention.

General Alexander has sent me a project with drawings, for removing the rock, which I inclose. It consists essentially of placing a coffer-dam of timber over the rock, pumping out the inclosed water and sinking a vertical shaft, from the bottom of which horizontal radial chambers are excavated for the reception of powder. Very heavy charges then being placed under the rock, it is presumed their explosion will shatter and break it up, and the fragments are to be removed by dredging or otherwise. His estimate for the excavations and blasting is $41,132 in coin, equivalent to $56,345 in United States legal tender notes

at 73 cents, their present price in this market, but it does not include the cost of removing the debris, for which no data was at hand. A second project has also been submitted to me by Mr. A. W. Von Schmidt, a prominent civil engineer of this city, which is also inclosed with this. It consists of placing on the rock a cylinder of boiler iron to serve the same purpose as the coffer-dam of General Alexander, and then excavating the rock in such a way that, when completed, there will remain only a shell; then, by means of heavy charges of powder, the shell can be broken up, and the debris falling down will be so small that twenty-four feet of water will be over the rock after the explosions. Mr. Von Schmidt offers to remove the rock, according to his plan, for $75,000 in currency, and give satisfactory and sufficient bonds for the performance of his contract.

I have reason to believe that other parties with other plans, not materially different from those above mentioned, would send in proposals, if invited, but I doubt if any one could come within the limit of the amount appropriated.

I am now impressed with the idea, from a careful investigation of all the plans submitted, that the most satisfactory way of removing this rock is by a plan similar in design to those of General Alexander and Mr. Von Schmidt, rather than by the method of drilling and blasting first recommended.

I have not the authority to make a contract to remove the rock for a specified sum, and the amount appropriated is not sufficient, I therefore refer the whole subject to you, and respectfully ask for instructions. I also request that an appropriation of $30,000, in addition to the former one, be asked for at the next session of Congress, to secure the removal of this rock, the estimate being based upon the amount of the proposal made by Mr. Von Schmidt, increased by $5,000 for surveys and contingencies.

I have the honor to be, very respectfully, your obedient servant,

R. S. WILLIAMSON,
Bvt. Lt. Col. U. S. A., Major of Engineers.

Maj. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A., Washington, D. C.

APPENDIX W.

Report of Brevet Brigadier General N. Michler, in charge of public buildings, grounds, and works in the City of Washington, D. C.

OFFICE OF PUBLIC BUILDINGS, GROUNDS, AND WORKS,
U. S. Capitol, Washington City, D. C., September 30, 1869.

GENERAL: The following statement in regard to the different duties which have been assigned me, and the progress which has been made in their execution during the fiscal year ending the 30th of June, is respectfully submitted for your information:

RIVER CHANNEL IMPROVEMENTS.

The system of improvements proposed for the channels of the Potomac in a special report upon the subject, made after a most careful survey and examination, has not yet received the consideration of the general government.

The corporate authorities of the city of Georgetown have, however, during the past summer caused the bar of the Virginia channel to be dredged to a depth of thirteen feet at mean low tide, and to a width of about eighty feet. Some thirty-three thousand cubic yards of mud were removed at a cost of less than ten thousand dollars.

In my last annual report attention was called to the great importance and necessity of taking immediate action in executing some plan of permanent improvement. As no appropriation has been made for the work, no steps have been taken towards prosecuting it during the present working season. Estimates are submitted for constructing the different sections, the sum total being required for its completion; the entire amount can be profitably expended during the present fiscal year.

BRIDGES.

Benning's Bridge.—This structure crosses the Anacostia or Eastern Branch, and is also known as the Upper Bridge. The flooring in particular, owing to the very great amount of travel passing over it, is very much worn along its entire length, and should be replaced by a new one.

Navy Yard Bridge.—A number of the beams are decayed, and the side-rails are old and unsafe. The draw, although not much used, is so constructed as to make travel over it at least very disagreeable, if not dangerous. It should be altered so as to conform to the level of the roadway of the bridge. The whole superstructure needs a thorough overhauling.

In reply to a resolution of the Senate of the United States, passed June 20, 1868, which directed me "to make a survey of the lower bridge, known as the Navy Yard Bridge, across the Anacostia, and report a plan for a permanent structure across the same, at or near the present site, capable of sustaining a railway track and cars, with a footway on each side of the carriage track, with an estimate of the cost of the same," a report and plans were prepared and submitted which furnished the required information.

The importance of a permanent and substantial bridge at or near the point indicated has been sufficiently well established; it is to be hoped that the necessary action will be taken to accomplish an object which is so much desired, and which will tend so much towards advancing the interests of the capital. Your attention is respectfully called to a consideration of the plans and the report accompanying them.

Potomac or Long Bridge.—The remarks made in my last annual report in regard to this bridge remain still in force, and prove the necessity of erecting a more substantial, suitable, and architectural structure. It is to be regretted that the river approaches to the city should present such unseemly appearances. As already stated, the Long Bridge has been for so many years the means of intercourse between the city and the opposite shore, that it would be very difficult to divert attention from the old well-beaten track. Such being the case, it is very desirable to replace the present one by another which would prove not only more ornamental and useful, but also be so planned as to remove some very serious obstructions created by the existing one, and which have a tendency to permanently injure the channels of the river. The present bridge constantly needs repairs; it is so old, and its timbers so badly decayed, that unremitting attention is required to insure safety to travelers. The old north draw has been replaced by an entirely new and lighter one, and by one which can be worked with

great ease; the other, near the south end of the structure, is heavy, badly constructed, expensive to keep in order, and difficult to move; at times it is a great annoyance to those compelled to pass over it by the detentions experienced when undergoing frequently needed repairs. It is now held together more by extra bracing, straining rods, and other appliances, than by the timbers employed in the original plan of construction; a new one of more modern design is greatly needed.

The cribs that support the long spans, near the Virginia shore, should all be rebraced and replanked. An entirely new floor will have to be laid during the next year. It is recommended that some necessary statutes be enacted to prevent the frequent occurrence of accidents to the draws by vessels running against the bridge while passing through them; these, in many cases, arise from carelessness in steering, and in others from too many vessels being towed through the channel at the same time. The damage to the channels of the river by this bridge have already been expatiated upon in several previous reports, and should receive serious attention. The railroad bridge, running parallel to and south of it, is also a serious cause of injury. Several plans for new and more architectural bridges have been prepared by order of Congress, but no subsequent action has been taken towards constructing them.

Aqueduct Bridge.—This bridge, leased by the Alexandria Canal Company, has been opened, in addition to canal purposes, for ordinary travel since the date of my last report. By the act relating to the Alexandria canal, approved July 27, 1868, it was enacted, "that as soon as the Chief Engineer of the Army shall certify to the Secretary of War that the said bridge is completed, the company may demand and receive certain specified tolls." In compliance with this law, directions were given me to inspect and report upon its completion, which was accordingly done, and the bridge thrown open to travel.

Chain Bridge.—This bridge over the Potomac, known also as the Little Falls Bridge, and situated about three miles above Georgetown, has been greatly improved during the last fiscal year. It had previously been in a very dilapidated and unsafe condition, the immense amount of army transportation passing over it during the continuance of the war having rendered it almost impassable. Very slight, if any, repairs had been attempted for several years. The two spans at the southern termination of the bridge had to be entirely rebuilt, and each of the others, eight in number, had to be repaired to a greater or less extent. The larger portion of the flooring had also to be renewed. A large amount of work remains still to be done to make the structure as it should be; many sections of the upper and lower chords should be replaced, as the timber is fast decaying away, and many slighter repairs should be attended to as soon as possible. It was found necessary for several weeks to close the Chain Bridge against all travel. The great inconvenience, as set forth in several petitions, to which farmers and others were placed by being compelled to cross the Aqueduct Bridge during that time, and the many complaints that were made by the citizens of Georgetown at the increased cost of marketing and other household wants in consequence of the demand for tolls over it, would seem to argue the very great necessity of preserving the former structure in perfect repair for their accommodation. Estimates are herewith submitted upon which to base the appropriations required to execute the different repairs of the several bridges enumerated; the necessity is fully exhibited by the accompanying table, which furnishes

the average amount of travel passing over them, per day and year, to and from the District of Columbia:

Travel.	Potomac (Long) Bridge.	Lower (Navy Yard) Bridge.	Little Falls (Chain) Bridge.	Upper (Benning's) Bridge.	Totals.
Foot passengers, one day	823	1,027	223	121	2,194
Foot passengers, one year	300,395	374,855	81,395	44,165	800,810
Horses and riders, one day	77	31	143	28	279
Horses and riders, one year	28,105	11,315	52,195	10,220	101,835
Horses and wagons, one day	277	278	160	59	774
Horses and wagons, one year	101,105	101,470	58,400	21,535	282,510
Teams and wagons, one day	192	231	185	80	688
Teams and wagons, one year	70,080	84,315	67,525	29,200	251,110
Cattle, one day	11	17	70	2	100
Cattle, one year	4,015	6,205	25,550	730	36,500
Hogs, one day	6	4	20	1	31
Hogs, one year	2,190	1,460	7,300	365	11,315
Sheep, one day	4	12	135	....	151
Sheep, one year	1,460	4,380	49,275	....	55,115

PUBLIC SQUARES, RESERVATIONS, NATIONAL PARK.

In making suggestions respecting the preservation and improvement of the different public squares and reservations throughout the city, and in again calling attention to the establishment of a national park among its environs, it would scarcely seem necessary to do more than refer to those already made in my last two annual reports. The subjects have been thoroughly discussed, and no additional recommendations can be made. Their important relation to the hygiene of the capital, the improved appearance offered to the streets and avenues, and the greatly enhanced value to property, not to dwell upon the means thereby furnished by the cultivation of a taste for the beautiful, are strong and sufficient arguments to continue the bestowal upon them of the care and expense required for their adornment. Owing to the very limited appropriations for the purpose, but little more has been done during the fiscal year than to endeavor to keep them in passable order. Lincoln Square has undergone greater improvement during the year than any other. It has been filled up and graded, and several hundred choice trees selected and planted. As soon as the necessary means are furnished it will be laid out in beds and walks, according to the design prepared for their arrangement. It is recommended that a suitable monument be erected within the inclosure.

The Capitol grounds have changed but very little. A considerable number of ordinary trees have been cut down to prevent the crowding and consequent injury of more valuable and beautiful species. Owing to the smallness of the appropriation the extension of these grounds progresses but slowly.

The culvert through the Botanical Garden has been completed, and is found fully capable of carrying off the immense quantity of water which is at times brought down by Tiber Creek. A new walk is being paved with the Seneca stone, and when completed will present a beautiful appearance in connection with the new conservatory now being constructed. The intermediate reservations between the Botanical Garden and the Smithsonian grounds have remained very much in the same condition as when last reported upon.

The Smithsonian grounds require a great deal of attention, and many additional improvements are needed to make the arrangements complete and in accordance with the original design. It is to be hoped that no further cause of delay may arise from the want of funds, and that the work may progress rapidly towards completion.

The grounds attached to the Agricultural Department are undergoing rapid alterations, and are being handsomely arranged with walks and drives in connection with ornamental plats for shrubs, plants, and trees.

The monument reservation still remains unchanged in its appearance. It is susceptible of being transformed into a place of very great adornment, particularly as it is located in such close proximity to the banks of the Potomac. The proposed plan for the laying out of the grounds immediately south of the White House, which includes the opening of a new avenue that will connect the streets passing by the Treasury building and the War and Navy departments, is being executed to the very utmost limit that the appropriation for the work will admit. It is very much to be regretted that an improvement which adds so much beauty to the surroundings of the building occupied by the chief executive officer of the nation, and one which will prove of so great convenience, can only be partially completed for the present. The consideration of the various plans submitted in my last reports for the embellishment and adornment of the different reservations known as the "Mall," with a view of uniting them in one grand drive extending from the Executive Mansion to the Capitol, is again respectfully asked.

The several squares—Lafayette, Franklin, Judiciary, and Scott—have been kept in as good state of preservation as the very limited means would permit. A new circle has been inclosed at the intersection of Massachusetts, Connecticut, and New Hampshire avenues. An additional square, corresponding with Scott square, has also been laid out near the junction of Connecticut avenue and K street. Several triangular reservations, at the crossings of Pennsylvania avenue by some of the lateral streets, were inclosed as soon as the government had ceased to occupy them with buildings for office purposes. Many of these have already been planted with trees while others still remain unimproved.

The great drought of the past summer has not only killed many of the trees and plants, but has interfered very materially with any other embellishment of the different grounds. The necessity for furnishing the latter with a sufficient supply of water by means of fountains, in order to preserve the vegetation, became very painfully apparent. It is earnestly urged that the attention of Congress be again called to the subject of a grand national park for the capital. Every important city in the country has acknowledged the necessity and wisdom of encouraging public places of resort for the purposes of pleasure and recreation; and individuals have lavished fortunes in the embellishment of private domains which are scarcely to be excelled by those endowed by the most munificent municipalities.

AVENUES AND STREETS.

To avoid repetition, reference must be again made to my last annual reports. As no appropriations were made by Congress for even the repair of avenues, to be expended during the last fiscal year, or for use during the present one, it is apparent that but little can be written upon the amount of work accomplished. The several recommendations in regard to their improvement and adornment that have been already offered are again presented for consideration. Sufficient provision should at least be made to pay the proportional part of the expense of any improvements which have actually been, or are proposed to be, made by the city authorities, and which pass by or through any of the public buildings and grounds. From the very nature of the contract

between the controlling powers, entered into at the time the capital was located on the banks of the Potomac, the government is bound to take some action. There are several very important suggestions in reference to them which should receive early attention. It is to be regretted that so many opposing interests interfere and prevent any well digested plan of operations. The repairing of that main thoroughfare through the capital, known as Pennsylvania avenue, has become an absolute necessity. For two entire fiscal years, the last and the one preceding, Congress has neglected to appropriate any money for attending to the many and much needed repairs along it, or for the purpose of simply keeping it in a cleanly and healthy condition. Two men, with a horse and cart, is the entire force engaged in removing the filth which accumulates over a distance of nearly three miles. A resolution passed the Senate of the United States, but which failed to be acted upon in the House of Representatives, appointing a special commission to decide upon the relative merits of the several plans for different pavements, and to select and lay one upon the avenue. The bill was very carefully drawn and considered, and should meet with general approval.

A special committee was also appointed to consider a change in the grades of the streets adjoining the Treasury Department; a report is being prepared upon the subject. Immediate attention should also be given to the regrading of the several streets encompassing the Patent Office building and the Post Office Department. There are still several very important avenues to be opened and graded; in their present condition many of them very seriously interfere with the improvements already made upon the streets. Those in particular which radiate from the Capitol building should receive prompt legislation. All the approaches to this magnificent structure should be placed in the most complete order; several of those leading from a northerly direction are quite impassable at the present time. The removal of the depot of the Baltimore and Ohio railroad from its present site will no doubt be again agitated. As two or three additional roads are in course of construction, or being favorably considered, the different companies may find it to their interests to unite upon some one central position for a depot to accommodate the travel and business of all of them.

It is particularly gratifying that the preliminary steps have been taken by the respective corporate authorities of Washington and Georgetown to unite the two cities by connecting West and P streets by a bridge over Rock Creek. This is a much needed structure, and will be one of great convenience to the public. Estimates are submitted for opening several of the avenues.

WASHINGTON CANAL—TIBER CREEK.

Much has been said and a great deal written on the subject of this great nuisance. It is gratifying to know that the municipal authorities have appointed a select committee to report some plan for its abatement, and it is to be hoped that early action will be taken in the matter. As the canal lies adjacent to, or passes through a large portion of the public grounds, it is but right and proper that Congress should aid by munificent appropriations any beneficial improvements that may be determined upon by those competent and authorized to act. It is not only a question to be decided in a commercial point of view, but also in its sanitary relations to the city. Many committees have been selected to report upon the subject, and many individual views have been expressed; the opinion seems to be unanimous that the canal should not

be longer used as an open sewer, and that in its present condition it is a great cause for creating and propagating diseases. In a report submitted several months ago by a board of engineers, detailed "to examine the model of an improved canal and ship-lock lock," and to consider "the value of the invention in facilitating commercial affairs of the country, and more especially its adaptation to aiding in the construction of a ship-canal through the city of Washington," the following remarks appear:

"The history, object, and condition of the Washington Canal have contributed a very considerable portion to the literature of the city for many years, and the various reports on the work in question, and projects for its improvement, would form a volume of matter of such magnitude as to render a revision of the whole subject too elaborate to be attempted here, especially as one does not appear to be necessary in this connection. The canal has been used since its construction for two purposes: the one for navigation, and the other as a main, open sewer; it has been the receptacle of the sewerage of the larger portion of the city, as well as of the surface drainage and the debris washed down through the bed of Tiber Creek. In consequence, it has been gradually filling up with a mass of most deleterious matter, and to such an extent as to render it not only entirely useless for the greater part of its length for the passage of boats, but to cause it to become a public nuisance. Attempts have been made during the last two or three years to partially abate the latter by removing a portion of the deposit by dredging, and by flooding the remainder by means of tide-gates; but after repeated efforts these means proved to be, as they were intended, only temporary expedients, and cannot be considered as having produced any very beneficial results.

"The various projects for the permanent improvement of the canal may be divided into three classes: the one proposes to continue the use of it, both for its legitimate purpose and as a sewer combined—in other words, to let it remain in its present status; the other, to employ it entirely for the transportation of boats, and to build a covered sewer parallel to it; while the third plan suggested is, to fill it up, excepting so much as may be necessary for a proper sewer, and discontinuing its use as a canal altogether.

"Mr. Bishop's (the patentee) project belongs to the first of these classes. In general terms he proposes to extend the canal up the river to Georgetown; to cut off the present sharp bends at different points; to place locks at its junction with the Potomac and the Eastern Branch; and to replace the present permanent bridges across it by turning or draw-bridges, in order to allow vessels of all descriptions to pass. In addition, as part of this plan, the Georgetown or Virginia channel of the Potomac is to be closed, and thus divert the tide of commerce from its present channel and direct it through the new one. He also contemplates to clear the canal and keep it free from objectionable matter by opening the gates and completely flooding it at certain stages of water in the river. Without entering into the details of this project it may be stated that the requirements of a navigable canal and a suitable sewer are incompatible, and that, in general, whatever tends to improve the one, necessarily injures the other. For example, a good sewer should have a declivity of at least one foot in one thousand, while the canal should be as nearly level as possible; the sewer should be no larger than is requisite to carry off all the semi-fluid mass or water that can find its way into it from its lateral branches or from surface drainage, while the larger the section of the canal, within reasonable limits,

the better; the sewer requires to be covered, while the canal remains open. The board cannot, therefore, recommend any project in which it is contemplated to use the same channel for the two purposes, however feasible the details of such an undertaking may be. It is a well known fact that along the wharves of all large cities there is a constant deposit from the contents of the sewers, which necessitates either almost continuous dredging, or the extension of the piers beyond its influence. There is no doubt that any canal, receiving the constantly accumulated matter from a great portion of the sewerage of a large city, must be filled sooner or later, unless there is a very strong and constant current through its entire length. In this case there is no possibility of producing such a current without extending the canal up to some point at or near the Chain or Little Falls Bridge, some three miles above Georgetown; even then the velocity of the water at the sides and bottom of a long narrow channel is so much retarded by friction, that, while there might be a sufficient strength to the current at the middle of the canal, a deposit would probably form on the sides and bottom. This would take place even in a constant current when the floating material is kept in motion and scarcely allowed to settle and become compact; how much more, then, would it obtain when locks were introduced, and the force of the water allowed to exert its influence only at intervals? That part of Mr. Bishop's project which contemplates the substitution of turning or draw bridges for the present permanent ones over the canal cannot reasonably be entertained. The canal now separates the main portion of the city from that section fronting on the Potomac, along which, at the present time, the larger number of wharves have been constructed for commercial purposes. To interfere or interrupt the constant travel and hauling of heavy freight on the streets leading from them would prove a very great injury to trade and the improvements now projected in their vicinity. Even should benefit arise to one part of the city by enlarging the dimensions of the canal so as to enable sea-going vessels to enter, it would scarcely compensate for the expense of the undertaking, and the damage that would be sustained by another and a very rapidly improving portion. Should the money necessary to execute such a work be applied to dredging and opening the old Washington channel along the whole water front of the city, it would prove a more profitable and beneficial expenditure. A long and continuous line of wharves, extending from the arsenal point to the foot of the Little Falls, could then be built. The closing, as intimated in the method of improvement referred to, of an old and well established channel like the Georgetown or Virginia one, for the purpose of opening another and a more circuitous one through the heart of a large city, would scarcely meet with very favorable consideration in any point of view. The only practicable and intelligent plan of operations is to accomplish by mechanical means what nature originally designed should be the case, the reopening of the old channels as they existed before any encroachments were made upon them, or any obstructions allowed to be interposed to their detriment. In closing this part of the report, the board cannot look upon the facts just stated as being in any way discouraging to those interested in the improvement of the Washington Canal. If it cannot be made to serve two purposes, there is no reason why it should not be made useful in accomplishing one good result; one object well accomplished will certainly prove more profitable than two imperfectly executed. It is susceptible of a mathematical demonstration, that should either the second or third of the general plans referred to for the improvement of the Washington Canal be adopted—in other words, should the canal be

properly cleaned out, narrowed, straightened as much as possible, and a good sewer built parallel with it, the arch over the lower portion of Tiber Creek being also extended as high up as the boundary of the city limits, or should the canal be discontinued as such, and a portion of its width converted into a proper sewer, and in connection with this should the main channel of the Potomac be diverted towards and along the Washington shore, the value of the land reclaimed and the rise in the price of property effected by the change, would more than pay the cost of the whole undertaking, to say nothing of the vast improvement that would accrue to the city by benefiting its sanitary condition.

"Several additional bridges of iron should be constructed over the canal at different points. There should be one in the prolongation of Sixth street; another should be substituted for the temporary wooden one in front of the Agricultural Department; and the third to connect the grounds south of the President's House with those around the Washington Monument. They should be made highly ornamental, of the same width as the streets, and upon the same level."

PUBLIC BUILDINGS.

The several public buildings still remain under the immediate charge of the different architects, or of some of the officials attached to the various departments. The Capitol has been completed, unless it shall be determined at some future time to enlarge the central part of the building; the Treasury building has also been finished.

A board of officers has also prepared plans and estimates for a new War Department building, but no action has yet been taken towards erecting it. The commission authorized to select a site and propose plans for a new State Department have had the subject under consideration, and will report at the next session of Congress.

The White House, with the several buildings and the grounds attached to it, has been undergoing some very important and necessary renovations; many more demand attention as soon as the liberality of Congress will furnish the means. The appropriations for the present fiscal year, which are to be applied to the care and refurnishing of the building, are entirely inadequate for the purpose. It is a very old structure; upon a very minute and careful inspection of all its parts, it was found to be sadly out of repair, and even destitute to a great extent of many of the conveniences which are now considered absolutely necessary for the comfort and health of individuals. Immediately after the inauguration of General Grant as President, the improvements were commenced and pushed forward as rapidly as possible. Several of the rooms have been repapered and painted, and others have been replastered and painted in colors. The library has been paneled and its ceiling frescoed. The walls and wood-work of the upper hall have been repainted, and a substantial and ornamental stairway leading to it substituted for the old one. The spacious hall, into which the entrance from the north portico opens, has also been painted and its ceiling frescoed. The furnaces have been overhauled, and new ranges introduced into the kitchens. A handsome and convenient billiard-room has been attached to the house. The conservatory has been placed in excellent order, and well filled with suitable plants; an additional section has been made to it during the summer to be used as a grapery, a large number of the choicest vines having been already introduced into it. Several beneficial changes have also been made in the garden. The stable has been enlarged and otherwise improved. The drainage and sewerage

through the grounds will need attention during the coming year. The entire exterior of the building should be repointed and painted. Many other much needed renovations could be suggested. The refurnishing of the mansion is being gradually effected. It is to be hoped that most liberal appropriations will be made by Congress to preserve and supply the building with all needful appendages, and render it in all its appointments a fit residence for the Chief Magistrate of the nation. Attention is again respectfully called to my report upon the selection of a site for a new presidential mansion.

WASHINGTON AQUEDUCT.

The earnest attention of the Chief of Engineers is again called to the condition of this great and important work. Its thorough completion is imperatively demanded, and the necessary appropriations should not longer be withheld. There is no public improvement throughout the District of Columbia which conduces so much toward the health and wants of the permanent residents of the capital, as well as the comfort of the many thousand transient visitors and government officials who seek it for pleasure or business, as the Washington aqueduct. It is the only safeguard against the destruction of not only private possessions, but also of the immense amount of public property accumulated within the limits of a few square miles. There is a wealth of important archives stored away within its boundaries that can never be replaced should they once be destroyed. In a sanitary point of view, as well as in an ornamental and mechanical consideration of the subject, the means for supplying a material so much enjoyed and so much needed should be furnished without hesitation and without stint. The annual report of the engineer of the Washington aqueduct is herewith appended. It furnishes in great detail a statement of the many repairs which have received attention during the year, and of the renovation of a few portions of the work which have hitherto been left in an unfinished or damaged state. He also dwells upon the pressing necessity of finishing other very important sections. Many very valuable suggestions are offered, and much useful information furnished. Reference is respectfully made to his report for a condensed account of the present condition of the aqueduct, and also of a summary of the total cost up to the present time, with an estimate of the necessary amount to be applied toward its completion. As so many complaints are made by many citizens as to the scarcity of water, and as such an utter wastefulness is indulged in by others, the adoption of some system, by which a more equal distribution can be arranged to the greater advantage of all seems to be imperative. Meters should be introduced into every house, as that plan appears to work well wherever applied.

It is again earnestly recommended to replace the old fire plugs on Pennsylvania avenue by new ones, and that they be connected directly with the government main along it.

The payment of the rents, and the purchase of the several small tracts of land which have been taken from private individuals for the use of the government, and which must be retained for the purposes of the aqueduct, is most earnestly urged. Several of them belong to widows, who are by no means in affluent circumstances. In some instances they have been compelled by the corporate authorities to pay the necessary taxes for the improvement of their property by the opening and repairing of streets, when, at the same time, they have been entirely dispossessed of its use for several years back. But a few thousand dollars

are needed to satisfy all such claims. As stated in my last report, "the great importance of introducing into the capital an unlimited supply of pure and wholesome water cannot be overestimated. The water thus furnished has become a great motive power at the different government workshops and buildings throughout the city; and when the capital of still the nation becomes what every enlightened citizen desires to see it, a larger demand will be made for both useful and ornamental purposes."

Including the estimates submitted for completing the Washington Aqueduct, the total cost of the work will not exceed four millions of dollars.

The estimates of amounts required to be appropriated for the public buildings, grounds, and works, under my charge, for the fiscal year ending the 30th of June, 1871, are herewith appended.

I am, general, very respectfully, your obedient servant,

N. MICHLER,
Major of Engineers, Bvt. Brig. Gen. U. S. A.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

OFFICE OF THE WASHINGTON AQUEDUCT,
Washington, D. C., October 1, 1869.

GENERAL: I have the honor to submit the following report of operations upon the Washington Aqueduct during the year ending September 30, 1869:

At the date of the last annual report, work had been suspended upon the construction of all the unfinished portions of the aqueduct, and the expenditures confined to such repairs as were absolutely necessary for the safety and preservation of the works.

In November an examination was made of the embankments of the distributing reservoir; it was apparent that they were very much worn by the action of the waves on their unprotected slopes, and it was deemed necessary for the safety of the reservoir to empty out the water. The twelve-inch main, leading from the pipe vault to Foundry Branch, was used for a drain, and the reservoir gradually emptied. It had been in use in its unfinished condition, for storage and settling purposes, over four years, and during that time the water supplied to Georgetown and Washington was generally clear and pure. Since then, being brought directly from the Potomac, it has often been muddy and impure.

The construction of this reservoir was suspended in June, 1864; owing to the failure of Congress to make any appropriation for its completion, no work has been done on it since. In form it is nearly a rectangle, 2,250 feet long and about 850 feet wide, with an area at the flow line of 44 acres. The level of its bottom is two feet above the bottom of the conduit at the influent gate-house, and fifteen feet above the center of the iron mains that lead from it at the effluent gate-house. With the water nine feet deep in the conduit, it is only seven feet deep in the reservoir, making its capacity at that depth equal to 94,500,000 gallons.

The work remaining to be done consists in excavating the bottom to an additional depth of thirteen feet; raising the dividing bank to the full height of the exterior banks; building a central gate-house in the dividing bank; building facings of rubble masonry on the interior slopes; completing the influent and effluent gate-houses, and the effluent screen well and pipe vault.

By excavating the bottom to the depth contemplated, which is the lowest at which water can be drawn through the mains, it would be twenty feet below the flow line, and the capacity would be 243,550,000 gallons; which would be sufficient, at the present rate of consumption, for twenty days' supply, and would allow of ample time for making any repairs to the conduit above that might be necessary.

In the Boston, New York, and Baltimore water-works annual examinations of the conduits from end to end have been found necessary, and annual repairs made to the masonry. On the Washington Aqueduct such examination and repair cannot be made until the completion of the distributing reservoir.

The conduit leading from Great Falls to the distributing reservoir is apparently in good condition. Extensive repairs have been made to its embankments, especially at culverts Nos. 18, 19, 20, 25, and 26.

The roadway over it has been kept in good order, but during wet weather the travel has necessarily been restricted to light loads. It has become the principal highway of Montgomery County, and should be macadamized.

The connecting conduit at the receiving reservoir has been in uninterrupted use since it was finished in August, 1867, until last March. Dalecarlia tunnel, which is in connection with this conduit, was commenced in 1864; it is built through rock that is not self-sustaining. During its construction the roof and sides were supported with timbers. In March a slide occurred near the shaft, which completely obstructed the flow of water, and rendered it necessary to shut it off from the conduit and pass it through the receiving reservoir. An examination of this tunnel was made in April, to ascertain the cause of the slide; it was found that the timbers that supported the roof and sides were very much decayed, and where the slide occurred they were crushed into fragments.

As many other places were in a dangerous condition, it was deemed true economy to expend a portion of the appropriation for superintendence and repairs in arching this tunnel. Accordingly arrangements were made for beginning the work; the slide was removed, new timbers were put in place of decayed ones, sand, cement, stones, and bricks were delivered in the vicinity of the work, and the arching was begun and continued until the middle of September, when it was suspended for the want of money. Over three hundred feet of the tunnel were securely arched, and a sufficient number of bricks purchased and delivered for arching the remainder.

During the progress of the work the roof and sides had to be shored with heavy timbers in order to protect the lives of the masons and laborers. It is estimated that over sixty thousand feet, board measure, of timber were used for this purpose. Many places, in that part of the tunnel yet to be arched, are safe only while the timbers remain sound; and the remainder of the tunnel should be arched without delay.

By referring to previous reports it will be seen that the estimated cost of arching 350 feet of this tunnel was $15,400. The amount expended has somewhat exceeded this sum; the increase is due to the fact that, since the estimate was made, nearly two years elapsed before the work was commenced; and in that time timbers decayed and masses of rock fell from the roof, greatly increasing the cost of the work. Every precaution was taken to protect the lives of the workmen, and only one man was injured.

The slopes of the embankments of the connecting conduit should be faced with ripraps to protect them from the waves of the receiving res-

ervoir; and as this reservoir will always be used for storing water, a substantial fence should be built around it to keep out the large droves of cattle that are driven to the pastures on the government lands in its vicinity.

POTOMAC DAM.

This structure was completed to its present height from the Maryland shore to Conn's Island, in December, 1867. Since then it has been subjected to the heaviest freshets of the Potomac, and the fact that it has sustained no damage from the large masses of ice and flood-wood that accompany the spring freshets, proves that it is impregnable.

During the months of August and September the water in the river above the dam was at a lower stage than at any time during the past ten years, and there was not sufficient in the Maryland channel to supply the conduit.

As soon as this fact became apparent, a survey was made of the river from the dam to the head of Conn's Island. At this point the river divides into two channels, and during low water the greater part of it flows down the Virginia channel. It was found necessary to deepen the upper end of the Maryland channel, and to construct temporary dams from the head of Conn's Island to the small islands above. Since this was accomplished the supply has been abundant.

The past season has been remarkable for the long-continued drought; very little rain has fallen since the middle of July, and the water in the river has been at its lowest stage. It has become evident that, in order to have sufficient water in the Maryland channel at all times, it will be necessary either to extend the dam entirely across the river, or to build a dam from the head of Conn's Island up the river to a point that will give sufficient head. The rocks, trees, and bushes between the dam and the head of the island should be removed, as they materially obstruct the flow of water during its low stages and affect its purity.

GATE-HOUSE AT GREAT FALLS.

The roof of the gate-house has been slated, the decayed wooden floor removed, and an iron floor, supported by cast-iron girders, has been substituted. The large timbers that supported the gates, being also decayed, were removed, and Phœnix wrought-iron "H" beams were put in their place. The lifting-screws, twenty in number, together with their gearing, were thoroughly cleaned and repaired, and have since been kept in good order.

TUNNEL NO. 1.

In tunnel No. 1, about six hundred feet below the gate-house, several cubic yards of rocks have fallen from the roof. As they do not materially obstruct the water, they have not been removed, but only rolled to the sides of the tunnel. It would be safer to remove them, and arch that part of the tunnel.

STONE BRIDGES.

Bridges Nos. 1, 2, 3, and 4 for many years have remained unfinished. Nos. 1 and 2 require coping; Nos. 3 and 4 require parapets and coping. No work has been done toward completing either of them since 1863. Estimates of the cost have been annually submitted, and will be found in the present report.

IRON BRIDGES.

Bridge No. 5, over College Pond, has been painted and is in good order. Bridge No. 6, over Rock Creek, has been painted and the floor repaired. The plank are very much worn, but probably can be made to last till next spring. The present floor was put down in 1865; it is not decayed, but it is worn out by the large amount of travel constantly passing over it. The floor-beams have been in use over ten years, and are very much decayed; they must soon be renewed.

PIPE LINE.

The pipe line is generally in good condition. All the vaults were cleaned and whitewashed, and the stop-cocks repaired. In Foundery Branch pipe vault a brick floor was laid. The stop-cocks on the thirty-inch, twenty-inch, and twelve-inch mains were cleaned and repaired, and new street boxes were set in place of decayed ones.

The twenty-inch main in North B street was completed to First street east, and a twelve-inch main laid in First street east from North B street to North A street; making complete the connection between the thirty-inch main in New Jersey avenue and the twelve-inch main on Capitol Hill.

WATER-PRESSURE ENGINE.

The water-pressure engine that supplies Georgetown Heights is in thorough repair. During the year new pistons were placed in the motive cylinders and new rings in the pumping cylinders. On the 21st of February one of the piston rods was broken, and a new one was put in its place. Owing to the increased consumption of water in the two cities, the pressure on the motive pistons has become reduced, and the engine does not supply as much water to Georgetown Heights as formerly.

In order to afford a full supply permission has been granted to the authorities of Georgetown to furnish and erect a steam pump in the engine-room, and to connect it with the mains of the high and low service.

HIGH-SERVICE RESERVOIR.

On Sunday, the 4th of April, the watchman reported a leak in the gallery of the high-service reservoir. The engine that supplies it was immediately stopped, all the dividing valves between the high and low service were opened, also several fire plugs, and the reservoir was rapidly emptied—not any too soon, however, as the leak, which when first discovered was a very small stream, before the reservoir was empty had increased in size equivalent to a stream three inches in diameter, and washed from the foundation about thirty-five cubic yards of clay. This was replaced with concrete made of broken bricks, sand, and cement, and as soon as the repairs were finished the water was again let in. It now contains half a million of gallons, which is kept as a reserve in the event of fires. This reservoir has been left for many years in an incomplete state, and its unfinished dome presents a very unsightly appearance. It should be cut down to the level of the gravel walk surrounding it, and inclosed by a substantial iron railing.

CONSUMPTION OF WATER.

Experiments were made during the summer on the flow of water in the conduit leading from the receiving to the distributing reservoir. The result showed that the two cities were consuming an average daily supply of about twelve million gallons.

Assuming that the population of the two cities is one hundred and thirty thousand, it makes the average daily consumption of water per head over ninety-two gallons.

A large proportion of this is consumed at the government departments, especially at the Navy Yard, where the aqueduct pressure is used to prove boilers, and at the Treasury, where two large fountains are constantly playing. The water that is wasted from them might be conveyed in a pipe to the vacant space at the intersection of Pennsylvania avenue with Louisiana avenue and Seventh street, and be used again for a similar purpose. On Capitol Hill and other high points the supply is not equal to the demand, because on the low points, where it is abundant, it is recklessly and willfully wasted. Periodically proclamations are issued by the city authorities forbidding the waste of Potomac water, to which not the slightest attention is paid.

Some additional legislation is necessary in reference to the proper control of the distribution of the water in both cities. In my opinion it should be entirely under the control of this office.

On the Cochituate, Croton, and Fairmount water-works the meter system is being gradually introduced in order to prevent unnecessary waste. It should be adopted in Georgetown and Washington, especially at hotels, livery stables, factories, and other establishments where large quantities of water are constantly used.

If, however, it is deemed desirable that the two cities shall have a supply sufficiently abundant for all purposes, it can be had only by completing the distributing reservoir, and laying an additional main of thirty or thirty-six inches in diameter from the effluent pipe vault to Capitol Hill. No estimate of the cost of laying a new main is submitted as by act of Congress, whenever it becomes necessary to lay additional mains, the expense thereof shall be borne by the corporations of Georgetown and Washington.

FIRE PLUGS.

On Pennsylvania avenue, between the Capitol and the Treasury Department, there are fifteen fire plugs. Two of them are in good order and connected with the twelve-inch main. The others are old and out of repair, and are connected with a pipe designated as the four-inch or spring pipe. This pipe is in a leaky condition, and nearly worn out. It is located parallel with the twelve-inch main, with which it is connected only at Third street west and Thirteen-and-a-half street west. Owing to its small diameter, and the distance between its connections, only two plugs can be supplied by it at a time.

It is respectfully suggested that the plugs which are worn out should be replaced by new ones, and that a new six-inch pipe should be laid in place of the four-inch.

It could connected with the twelve-inch main at Third, Sixth, Twelfth, Thirteen-and-a-half, and Fourteenth streets west. With this accomplished, Pennsylvania avenue would have a bountiful supply of water in the event of fires. As it is now, there is a deficiency, and steamers have to obtain their supply from other streets.

LANDS.

The lands occupied by the Washington Aqueduct, and to which the United States have no title, are described as follows: At Great Falls, 5.44 acres, belonging to the estate of the late Hall Neilson. In Montgomery County, the road across the farms of Jackson, Collins, Brooke, and Anderson. In Georgetown, at the high-service reservoir, a lot of land fronting on High street, and partly covered by the reservoir embankment, owned by Mrs. E. M. Mosher. At bridge No. 6, a lot fronting on Montgomery street, the property of Mrs. Maria C. French. Each of the above-described parcels of land will be required always for the use of the Washington Aqueduct, and an appropriation should be made for their purchase.

FINANCIAL STATEMENT

At the date of the last annual report the balance in the Treasury applicable to this work was	$32,077 88
Appropriated by Congress for engineering, superintendence, and repairs, for the year ending June 30, 1870	25,000 00
Total	57,077 88

The expenditures to date are as follows:

For amount of retained percentage due contractors for the construction of the Potomac dam	$5,247 64
For construction of gate-house at Great Falls	1,302 94
For arching with bricks laid in cement a portion of Dalecarlia tunnel	17,792 34
For purchase of 500,000 bricks from the United States arsenal for Delecarlia tunnel	2,102 50
For raising and widening embankments over conduit	1,745 07
For putting iron beams and iron floor in gate-house at Great Falls	1,061 15
For repairs to water-pressure engine at bridge No. 6	609 39
For painting bridge No. 6	895 68
For office rent	375 00
For office expenses, including gas, fuel, and stationery	153 39
For engineering, superintendence, and repairs	18,063 38
For balance remaining on hand September 30, 1869	7,729 40
Total	57,077 88

From the above statement it appears that the amount remaining to the credit of the Washington Aqueduct is only $7,729 40. This sum will not be sufficient for ordinary expenses during the remainder of the fiscal year. By referring to the last annual report it will be seen that the estimated amount for engineering, superintendence, and repairs for the year ending June 30, 1870, was $33,000; Congress appropriated only $25,000; leaving a deficiency of $8,000.

Estimate of the cost of completing the Washington Aqueduct:

For rent and purchase of $5\frac{44}{100}$ acres of land at Great Falls	$1,320 00
For purchase of road-way from Great Falls to conduit road, $2\frac{3}{10}$ miles, $18\frac{4}{10}$ acres	1,012 00

For purchase of road-way across land owned by William Brooke	$550 00
For rent and purchase of land at high-service reservoir in Georgetown	3,300 00
For rent and purchase of land at bridge No. 6, in Georgetown	2,640 00
For excavating and removing rocks, trees, and bushes from the Maryland channel of the Potomac above the Potomac dam	5,500 00
For lining with bricks a part of tunnel No. 1	1,650 00
For finishing with cut stone bridges Nos. 1, 2, 3, and 4	27,500 00
For widening and raising embankments over conduits, and macadamizing roads	11,000 00
For completing the lining of Dalecarlia tunnel with bricks	12,000 00
For excavating the bottom of the distributing reservoir to an additional depth of thirteen feet and lining the interior slopes with rubble masonry laid in cement	411,115 00
For completing gate-house at the distributing reservoir	44,538 00
For completing high service reservoir	8,800 00
For protecting with ripraps the water face of the connecting conduit embankments	11,000 00
For ventilators over conduit	3,080 00
For fencing conduit and reservoirs	21,000 00
For building office at bridge No. 6	3,300 00
For engineering, superintendence, and repairs for the fiscal year ending June 30, 1870	30,000 00
Total	599,305 00

All of the unfinished work described in the foregoing estimate, with the exception of the distributing reservoir, can be completed during the next fiscal year if Congress will make the necessary appropriation. The aggregate amount of which, including a sufficient sum for engineering, superintendence, and repairs, is $188,190. If to this be added the amount that can be advantageously expended in continuing the construction of the distributing reservoir, $200,000, the total will be $388,190.

Summary of the appropriations made by Congress for the Washington Aqueduct.

April 30, 1852	$5,000 00
March 3, 1853	100,000 00
March 3, 1855	250,000 00
August 18, 1856	250,000 00
March 3, 1857	1,000,000 00
June 12, 1858	800,000 00
June 25, 1860	500,000 00
July 4, 1864	150,000 00
July 28, 1866	142,584 00
December 20, 1866	12,000 00
March 2, 1867	20,000 00
July 25, 1868	52,000 00
March 3, 1869	25,000 00
Total	3,307,084 00

If to this be added the amount of the estimated cost of completing the Washington Aqueduct	$599,305 00
The total will be	3,906,389 00

A comparatively small amount when compared with the sums already expended by the cities of Boston, New York, Philadelphia, and Baltimore, for similar purposes.

The cost of extending the Potomac dam entirely across the river, to the Virginia shore, is not included in the present estimate; because the completion of the distributing reservoir to its contemplated depth will give a large storage capacity, and obviate the necessity of further extending the dam for many years to come.

I am, general, very respectfully, your obedient servant,

THEODORE B. SAMO,
Chief Engineer.

Brevet Brigadier General N. MICHLER,
Major of Engineers U. S. Army, in charge of Public Buildings, &c.

Estimates of appropriations which will be required for public buildings, grounds, and works, under the direction of the Chief Engineer of the War Department, for the fiscal year ending June 30, 1871.

Objects of expenditure.	Date of acts, resolutions, or treaties authorizing or providing for the expenditure.	References to the Statutes at Large, (*Little, Brown & Co.'s edition.*) Vol.	Page.	Sec.	Estimated amount which will be required for each detailed object of expenditure.	Total amount to be appropriated under each head of appropriation, in addition to the estimated amount which will be on hand at the beginning of the fiscal year.	Estimated balance which will be on hand unexpended at the close of the current fiscal year, and which will be required in addition to the amounts estimated for.	Date of last appropriation act.	Amount of last appropriation.
Improvement, care, and repair of public buildings, grounds, and works in the District of Columbia.									
For casual repairs of Navy Yard and Upper bridges	July 20, 1868	Pam.	8	......	$14,500 00	$14,500 00	....	March 3, 1869	$3,000
For repairs of bridge at or near the Little Falls, and to pay a deficiency	July 20, 1868	Pam.	8	......	10,000 00	10,000 00	....	March 3, 1869	2,000
For repairs of Long bridge, District of Columbia	July 20, 1868	Pam.	8	......	20,000 00	20,000 00	....	March 3, 1869	5,000
For fuel for President's house	July 20, 1868	Pam.	8	......	5,000 00	5,000 00	....	March 3, 1869	5,000
For repairs of Pennsylvania avenue, and sprinkling and keeping it clean, and for new crossings on the same.	March 2, 1867	12	467	1	20,000 00	20,000 00	....	March 2, 1869 July 25, 1868	7,500
For public reservation No. 2, and Lafayette square	July 20, 1868	Pam.	8	......	15,000 00	15,000 00	....	March 3, 1869	2,000
For care and improvement of grounds south of the President's house	July 20, 1868	Pam.	8	......	5,000 00	3,000 00	....	March 3, 1869	5,000
For removing snow and ice from pavements and public walks	July 20, 1868	Pam.	8	......	1,000 00	1,000 00	....	March 3, 1869	500
For repair of government water pipes and fire plugs on Pennsylvania avenue.	July 20, 1868	Pam.	8	......	5,000 00	5,000 00	....	July 25, 1868	500
For manure and hauling, for public grounds and reservations	July 20, 1868	Pam.	8	......	3,000 00	3,000 00	....	March 3, 1869	2,000
For improvement and care of reservations on New York, Pennsylvania, Maryland, Massachusetts, Vermont, Connecticut, and other avenues.	July 20, 1868	Pam.	8	......	15,000 00	15,000 00	....	March 3, 1869	3,000
For painting iron fences around Lafayette square; in front of War and Navy Departments, Judiciary square, &c.	July 20, 1868	Pam.	8	......	5,000 00	5,000 00	....	March 3, 1869	3,000
For annual repairs, and repainting the exterior of the President's house.	July 20, 1868	Pam.	8	......	10,000 00	10,000 00	....	March 3, 1869	10,000
For refurnishing the President's house	July 20, 1868	Pam.	8	......	20,000 00	20,000 00	....	March 3, 1869	25,000
For flower-pots, mats, twine, &c	July 20, 1868	Pam.	8	......	1,000 00	1,000 00	....	March 3, 1869	1,000
For fuel for centre building of Capitol	July 20, 1868	Pam.	8	......	1,500 00	1,500 00	....	March 3, 1869	1,500
For continuing the grading of Virginia avenue	March 2, 1867	12	463	1	10,000 00	10,000 00	....	March 2, 1867	25,000
For an iron fence around Franklin square, &c	....	......	......	......	20,000 00	20,000 00	....	....	......
For completing the iron fence around the Botanical Garden, and paving the walks of the same.	March 2, 1867 March 3, 1867	Pam. 12	10 463	 1	30,000 00	30,000 00	....	March 2, 1867 March 3, 1867	20,000

Estimates of appropriations which will be required for public buildings, grounds and works, under the direction of the Chief Engineer of the War Department, for the fiscal year ending June 30, 1871—Continued.

Objects of expenditure.	Date of acts, resolutions, or treaties authorizing or providing for the expenditure.	References to the Statutes at Large, (*Little, Brown, & Co.'s edition.*) Vol.	Page.	Sec.	Estimated amount which will be required for each detailed object of expenditure.	Total amount to be appropriated under each head of appropriation, in addition to the estimated amount which will be on hand at the beginning of the fiscal year.	Estimated balance which will be on hand unexpended at the close of the current fiscal year, and which will be required in addition to the amounts estimated for.	Date of last appropriation act.	Amount of last appropriation.
For further improvement of Lincoln square	July 25, 1866	12	251	1	$10,000 00	$10,000 00	....	March 2, 1868	$8,000 00
For hire of carts on public grounds	March 2, 1867	12	462	1	3,000 00	3,000 00	....	March 3, 1869	2,000 00
For purchase and repair of tools for public grounds	March 2, 1867	12	462	1	2,000 00	2,000 00	....	March 3, 1869	1,500 00
For the purchase of trees and tree-boxes, to whitewash tree-boxes, fences, &c.	March 2, 1867	12	462	1	5,000 00	5,000 00	....	March 3, 1869	2,000 00
For annual repairs of fences around reservations	March 2, 1867	12	462	1	2,000 00	2,000 00	....	March 2, 1867	1,000 00
For cleaning out sewer traps along Pennsylvania avenue	March 2, 1867	12	462	1	1,000 00	1,000 00	....	July 25, 1868	500 00
For lighting the President's house, Capitol, public grounds, &c., &c	July 20, 1868	Pam.	8	......	40,000 00	40,000 00	....	March 3, 1869	30,000 00
For pay of lamp-lighters, plumbing, gas fitting, &c., &c	July 20, 1868	Pam.	8	......	10,000 00	10,000 00	....	March 3, 1869	5,000 00
For contingents of office of public buildings, &c	July 20, 1868	Pam.	8	......	2,000 00	2,000 00	....	March 3, 1869	1,000 00
For improving Massachusetts, Connecticut, New York, Maryland, Delaware, and New Jersey avenues.	....	......	......	......	25,000 00	25,000 00	....	....	....
For expenses to be incurred in the improvement of streets, avenues, and alleys passing by or through the property of the United States, and to abate nuisances.	July 25, 1868	......	......	......	100,000 00	100,000 00	....	July 25, 1868	50,000 00
For an iron bridge across the canal at Thirteenth street west	....	......	......	......	20,000 00	20,000 00	....	....	....
For improvement, care, protection, &c., of seats and fountains in the Capitol grounds.	March 3, 1869	Pam.	10	......	2,000 00	2,000 00	....	March 3, 1869	1,000 00
For improvement of Monumental reservation	....	......	......	......	5,000 00	5,000 00	....	....	....
For construction of circular fence around and through the President's grounds to Seventeenth street, including foundation walls, curbing, flagging, iron fencing, &c., &c., 3,640 running feet.	March 3, 1869	Pam.	10	......	91,000 00	50,000 00	....	March 3, 1869	27,000 00
For cutting street through the President's grounds, as per plan	....	......	......	......	1,192 00	1,192 00	....	....	....
For macadamizing 17,055 square yards of road, including paving, gutters, gate posts, &c.	....	......	......	......	39,000 00	39,000 00	....	....	....
For 4,428 running feet of fence stone, fence, and curb, on Fifteenth street, Canal street, and Seventeenth street; 88,400 square feet of brick paving along same; gates and gate posts on said streets.	....	......	......	......	91,000 00	50,000 00	....	....	....
For additional repairs of the green-house at the President's house, and purchase of plants	....	......	......	......	5,000 00	5,000 00	....	July 25, 1868	5,000 00

For repairs of green-houses in the propagating garden	......	......	......	......	3, 000 00	3, 000 00	......	......	......
Total	......	......	......	......	668, 192 00	584, 192 00	......	......	......
33 *For compensation of persons employed on and about the public buildings, grounds, and works.*									
Clerk in office of public buildings, &c	Aug. 31, 1852	10	91		$1, 200 00	$1, 200 00	......	......	$1, 200 99
Messenger in office of public buildings	March 3, 1859	11	421	1	840 00	840 00	......	......	840 00
Public gardener	March 3, 1851	9	612	1	1, 440 00	1, 440 00	......	......	1, 440 00
Foreman and twenty-one laborers in public grounds	Feb. 25, 1863 March 3, 1851	9 12	613 694	1	19, 296 00	19, 296 00	......	......	19, 296 00
Laborer in charge of water closets in Capitol	March 2, 1867	Pam.	456	1	720 00	720 00	......	......	720 00
Four laborers in the Capitol	Feb. 25, 1863	12	750	4	2, 880 00	2, 880 00	......	......	2, 880 00
Furnace keeper under the old hall of the House of Representatives	Feb. 25, 1863	12	694	1	864 00	864 00	......	......	864 00
Furnace keeper in President's house	Aug. 18, 1856	11	117	1	720 00	720 00	......	......	720 00
Two policemen at President's house	March 2, 1867	13	456	1	2, 640 00	2, 640 00	......	......	2, 640 00
Two night watchmen at President's house	March 2, 1867	13	456	1	1, 800 00	1, 800 00	......	......	1, 800 00
Door-keeper at President's house	Aug. 31, 1852	10	91	1	1, 000 00	1, 000 00	......	......	1, 000 00
Assistant door-keeper at President's house	Aug. 31, 1852	10	91	1	600 00	600 00	......	......	600 00
Two draw-keepers at two bridges across the Eastern Branch, and fuel, oil, lamps, &c.	Aug. 31, 1852	10	92	1	1, 632 00	1, 632 00	......	......	1, 632 00
Eight draw-keepers at Long bridge, and fuel, oil, lamps, &c	March 2, 1867	13	456	1	7, 570 00	7, 570 00	......	......	7, 570 00
Five watchmen in Public reservation No. 2	March 2, 1867	13	456	1	3, 000 00	3, 000 00	......	......	3, 000 00
Watchman in Franklin square	Feb. 28, 1866	13	315	1	600 00	600 00	......	......	600 00
Electrician to light Capitol dome, &c	March 2, 1867	13	463	1	1, 200 00	1, 200 00	......	......	1, 200 00
Person to take charge of heating apparatus of Library of Congress	March 2, 1867	13	456	1	1, 000 00	1, 000 00	......	......	1, 000 00
Total	......	......	......	......	49, 002 00	49, 002 00	......	......	49, 002 00
For completing the Washington aqueduct, and for superintendence and repairs for the fiscal year ending June 30, 1871.									
For rent and purchase 5.44 acres of land at Great Falls	March 3, 1853	10	206	......	$1, 320 00	$1, 320 00	......	......	......
For purchase of roadway from Great Falls to Conduit road	March 3, 1853	10	206	......	1, 012 00	1, 012 00	......	......	......
For purchase of roadway across land owned by William Brooke	March 3, 1853	10	206	......	550 00	550 00	......	......	......
For rent and purchase of land at high-service reservoir	March 3, 1853	10	206	......	3, 300 00	3, 300 00	......	......	......
For rent and purchase of land at bridge 6	March 3, 1853	10	206	......	2, 640 00	2, 640 00	......	......	......
For removing rocks, excavating channel, &c., of the Potomac River above the dam.	March 3, 1853	10	206	......	5, 500 00	5, 500 00	......	......	......
For lining part of tunnel No. 1	March 3, 1853	10	206	......	1, 650 00	1, 650 00	......	......	......
For finishing bridges Nos. 1, 2, 3, and 4	March 3, 1853	10	206	......	27, 500 00	27, 500 00	......	......	......
For widening and raising embankments, and macadamizing roads, &c	March 3, 1853	10	206	......	11, 000 00	11, 000 00	......	......	......
For completing the lining of Dalecarlia tunnel	March 3, 1853	10	206	......	12, 000 00	12, 000 00	......	......	......
For excavating the bottom of the distributing reservoir to an additional depth of thirteen feet, and lining the interior slopes with rubble masonry.	March 3, 1853	10	206	......	411, 115 00	200, 000 00	......	......	......
For completing gate house at the distributing reservoir	March 3, 1853	10	206	......	44, 538 00	44, 538 00	......	......	......
For completing high-service reservoir	March 3, 1853	10	206	......	8, 800 00	8, 800 00	......	......	......

Estimates of appropriations which will be required for public buildings, grounds and works, under the direction of the Chief Engineer of the War Department, for the fiscal year ending June 30, 1871—Continued.

Objects of expenditure.	Date of acts, resolutions, or treaties authorizing or providing for the expenditure.	References to the Statutes at Large, (*Little Brown, & Co.'s edition.*) Vol.	Page.	Sec.	Estimated amount which will be required for each detailed object of expenditure.	Total amount to be appropriated under each head of appropriation, in addition to the estimated amount which will be on hand at the beginning of the fiscal year.	Estimated balance which will be on hand unexpended at the close of the current fiscal year, and which will be required in addition to the amounts estimated for.	Date of last appropriation act.	Amount of last appropriation.
For protecting with ripraps the water-face of the connecting conduit embankments.	March 3, 1853	10	206	......	$11,000 00	$11,000 00	....	....	....
For ventilators over conduit........	March 3, 1853	10	206	......	3,080 00	3,080 00	....	....	....
For fencing conduit and reservoirs........	March 3, 1853	10	206	......	21,000 00	21,000 00	....	....	....
For building office at bridge No. 6........	March 3, 1853	10	206	......	3,300 00	3,300 00	....	....	....
For engineering, superintendence, repairs, &c........	March 3, 1853	10	206	......	30,000 00	30,000 00	....	March 3, 1869	$25,000 00
Total........	....	......	......	......	599,305 00	388,190 00	....	....	25,000 00
For the improvement of the Virginia and Washington channels of the Potomac and opening of a new channel.									
For the removal of the causeway of the Long bridge, and to replace the same by a bridge upon piles.	March 2, 1867	......	......	......	$25,000 00	$25,000 00	....	....	....
For dredging the Virginia and Washington channels........	March 2, 1867	......	......	......	8,000 00	8,000 00	....	....	....
For dredging a channel eight feet deep and from 250 to 300 feet wide between Easby's Point and the eastern draw of Long bridge, 300,000 cubic yards, at 30 cents.	March 2, 1867	......	......	......	90,000 00	90,000 00	....	....	....
Total........	....	......	......	......	123,000 00	123,000 00			

Summary of estimates.

For the improvement, care, and repair of public buildings, grounds, and works in the District of Columbia........	$584,192 00
For compensation of persons employed on and about the public buildings, grounds, and works........	49,002 00
For completing the Washington aqueduct, and for superintendence and repairs for the fiscal year ending June 30, 1871........	388,190 00
For the improvement of the Virginia and Washington channels of the Potomac, and opening of a new channel........	123,000 00
Total........	1,144,384 00

OFFICE OF PUBLIC BUILDINGS, GROUNDS, AND WORKS,
U. S. Capitol, Washington, D. C., April 6, 1869.

GENERAL: I have the honor to acknowledge the receipt of your letter of the 3d instant, inclosing a communication from the Hon. B. C. Cook, chairman of the Committee on the District of Columbia, together with a copy of a resolution of the House of Representatives, in relation to the present condition of the Washington aqueduct. * * * *

The Washington aqueduct was originally projected upon its present general plan and location by Captain M. C. Meigs, United States Corps of Engineers. Its construction was begun A. D. 1853, on the 8th day of November. The engineers in charge have been as follows: Captain M. C. Meigs, from November 3, 1852, to July 17, 1860; Captain H. W. Benham, from July 17, 1860, to December —, 1860; Lieutenant J. St. Clair Morton, from December —, 1860, to February 22, 1861; General M. C. Meigs, from February 22, 1861, to June 18, 1862, when the supervision of the work was transferred by act of Congress from the War Department to the Department of the Interior.

Under the Department of the Interior the engineers in charge have been as follows: William R. Hutton, from June 18, 1862, to July 21, 1863; Silas Seymour, from July 21, 1863, to June 5, 1865; Theodore B. Samo, from June 5, 1865, to April 19, 1867, when the supervision of the work was transferred by act of Congress from the Interior Department to the War Department, and placed under the charge of the Chief Engineer of the army.

The departures that have been made from the original plans of Captain Meigs are as follows:

1. A dam of solid masonry at Great Falls, instead of an embankment of broken stone.
2. A connecting conduit around the lower end of the receiving reservoir.
3. Slope-wall facing for the inner slopes of the distributing reservoir, instead of facings of small broken stones.
4. Raising the dividing bank in the distributing reservoir to the full height of the outer banks, and the construction of a gate-house therein, so as to allow of the independent use of either section of the reservoir.
5. Excavating the bottom of the distributing reservoir to an additional depth of thirteen feet, so as to increase the purity of the water, and afford twice the amount of storage capacity.

The construction of the Potomac dam was begun in August, 1864, and continued until January, 1865. On account of no appropriation having been made by Congress until late in July, 1866, the work was not resumed until the 9th of August, when it was continued until December 20, and then suspended for the winter. The work was again resumed June 20, 1867, and continued until the completion of the foundation and superstructure masonry, December 20, 1867. The dam, as now constructed, extends from the Maryland shore to Conn's Island, a distance of 995 feet, and gives a head of six feet of water in the aqueduct, or a daily supply of about fifty million gallons. It is contemplated, ultimately, to build the dam entirely across the river to the Virginia shore, of sufficient height to insure a supply equal to the full capacity of the aqueduct, which is about eighty million gallons daily. During the construction of the Potomac dam the work was often damaged and interrupted by freshets, but since the completion of the foundation and superstructure masonry it has sustained no damage, and an examination made on the second instant shows that it has again successfully withstood the spring freshets of the Potomac and is in good condition.

It is well and substantially constructed in accordance with the terms of the contract.

The connecting conduit was begun in July, 1864, and the work continued until April 1, 1865, when, on account of no appropriation having been made by Congress until July 28, 1866, the work was suspended. It was resumed early in August, 1866, and prosecuted until its completion August 8, 1867, when the waters of Powder Mill Branch and the receiving reservoir were shut off, and the water of the Potomac, which, since December, 1863, had emptied into the receiving reservoir, was turned into the new conduit. This work was substantially constructed and is in good condition, except Dalecarlia tunnel, which is constructed through loose rock that is not self-sustaining, and the roof is supported with timbers. An estimate of the cost of arching this tunnel was made and submitted to Congress October 1, 1867, and October 1, 1868. No appropriation, however, was made, and recently a number of the timbers which had been in place since 1864 decayed and broke, and a large mass of the loose rock fell from the roof and choked up the tunnel. If an appropriation for arching this tunnel had been made in 1867 this accident would not have happened. As more than three hundred feet of the roof are supported by timbers it is probable that, during the present year, other slides will occur and largely increase the estimated cost of arching. The embankments over the connecting conduit are washed by the waves of the reservoir, and an appropriation to protect their slopes with rip-raps has been asked for.

No appropriation has been made for the distributing reservoir since June, 1860, and no work has been done on it since June, 1864; since then it has been used, in its unfinished condition, for storage and filtering of water until last November, when an examination showed that its unprotected banks were very much worn by the waves, and that there was danger of their giving way; the water was, therefore, shut off from the reservoir and it was gradually emptied. The gate-houses in connection with it are all unfinished, and no work has been done on either of them since June, 1864.

Other portions of the Washington aqueduct are yet unfinished and are as follows:

At Great Falls, a part of tunnel No. 1 requires arching.

Stone bridges 1 and 2 require coping.

Stone bridges 3 and 4 require parapets and coping.

The roadway over the conduit (being used for a public highway) should be macadamized.

At Georgetown, the high-service reservoir should be finished.

The necessity of completing the unfinished portions of the Washington aqueduct has been fully shown in the annual reports of the engineers in charge, and detailed estimates of the cost submitted to Congress, as will be seen by reference to the accompanying reports, dated 1864 to 1868, inclusive.

The conduit, from Great Falls to the distributing reservoir, has a diameter of nine feet, with a fall of nine and a half inches to the mile, and can discharge into the reservoir, with the present height of the Potomac dam, over fifty million gallons of water daily. From the distributing reservoir the water is conveyed to Georgetown and Washington through two iron mains of twelve and thirty inches diameter respectively; these two mains have been taxed to their utmost capacity for several years, and there has been a constant complaint from the consumers of the deficient supply. The only remedy for this is to complete the distributing reservoir and lay another main of thirty or thirty-six

inches diameter from the distributing reservoir to Capitol Hill. The following is extracted from the first annual report of Captain Meigs, dated February 12, 1853:

"The mains leading from the reservoirs are, I think, enough for the present. In a few years it will be necessary to enlarge them. Then the twelve-inch can be taken up and relaid in the distribution of the city, its place being supplied by one of thirty-six inches."

Since December, 1863, the supply of water has been uninterrupted; the amount daily consumed is about twelve million gallons—less than one-fourth of the amount at present supplied by the conduit; the surplus, for want of mains to bring it to the city, is wasted at the several waste-weirs of the conduit.

The quality of the water consumed is similar to that in the river at the Great Falls. When the river is swollen during freshets the water in the city is muddy and impure; this will be the case until the distributing reservoir is completed.

In regard to the lands occupied by the Washington aqueduct I beg leave to refer to page 23 of my annual report, dated October 1, 1868, where a description of them will be found. The land at Great Falls was taken for the use of the Washington aqueduct by Captain Meigs in 1853. There has been paid for it a nominal rental of ten dollars and eighty-eight cents per annum.

The road across the farms of Jackson, Collins, and Anderson, was taken for the use of the Washington aqueduct by Silas Seymour in 1863; no compensation has been paid.

The road across the farm of Wm. Brooke was taken for the use of the Washington aqueduct by Silas Seymour in 1863 or 1864. A verbal agreement was made that the United States should fence both sides of the road and buy the land at a fair valuation. One side of the road has been fenced and a yearly rental of twenty-five dollars has been paid.

In Georgetown the lot owned by Mrs. Mosher, and the lot owned by Mrs. French, were taken for the use of the Washington aqueduct by Captain Meigs in 1861; no compensation has been paid for either lot.

The papers inclosed in yours of the 3d instant are herewith returned.

I am, general, very respectfully, your obedient servant,

N. MICHLER,
Major of Engineers, Brevet Brigadier General U. S. A.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

OFFICE OF PUBLIC BUILDINGS, GROUNDS, AND WORKS,
U. S. Capitol, Washington, D. C., August 20, 1869.

GENERAL: The following is a copy of a letter, dated on the 14th inst., which has been addressed to the Hon. Secretary of War by a committee on the part of the corporate authorities of the city of Georgetown, in relation to the probable extent of damage and injury, if any, that may be done the Georgetown or Virginia channel of the Potomac River by the repairs now being made upon the railroad bridge across it:

GEORGETOWN, D. C., *August* 14, 1869.

DEAR SIR: The undersigned, a committee on the part of the corporate authorities of the city of Georgetown, D. C., respectfully represent that, having been advised that certain repairs are being made upon the railroad bridge over the Potomac River, which may have the effect to impair and destroy the channel of that river so far as the port of Georgetown is concerned, and being desirous of ascertaining the probable extent of

such damage and injury from those most competent to give an opinion upon the subject, they request that you will cause an examination to be made for this purpose by the proper officers of your department, and the result communicated to the corporate authorities of our city.

Very respectfully, your obedient servants,

H. M. SWEENY, *Mayor.*
CHAS. F. PECK, *Recorder, &c.*
JOS. L. SIMMS.

General JOHN A. RAWLINS, *Secretary of War.*

The above letter was referred to me, with instructions to give immediate attention to the subject, and to report the result of my examination. In connection with this matter, I respectfully submit for your information the two inclosed letters, marked A and B. The first was addressed to the receiver of the Washington, Alexandria, and Georgetown Railroad Company, calling his attention to the plan being executed by said company for the repairs of the railroad bridge, and respectfully remonstrating against the adoption of it, believing that it would prove, during the winter and seasons of freshets, not only damaging to that bridge, as well as the one known as the Long or Potomac bridge, running parallel to it, but also, by further obstructing the bed of the river, tend to injure the main and only channel communicating with Georgetown. While the commercial interests of the latter place must ever be jealous of any encroachment or any obstructions which might prove even in the slightest degree detrimental to the channel, it is equally important that an unbroken communication by rail should be had between the North and South; but both interests can be conserved by adopting a liberal and comprehensive policy. The railroad company could have accepted other plans for the strengthening of certain spans of the bridge than the one adopted by piles, such as the one which is now being used in other spans of the same work; they might not all be equally economical, but would certainly prove equally efficacious, and at the same time remove all the cause of fear as to injuring the channel. The second letter, marked B, is in reply to the former one. In this the receiver states that the "piles now being driven in the southern channel of the river for the support of the five long spans of the bridge are only intended as a temporary means of strengthening the bridge to accommodate the demand of the public for immediate travel, and to be used as false works in the construction of a more suitable structure at that point, to be erected at an early day; various plans for which have already been submitted, but not yet fully decided upon." This reply I deemed perfectly satisfactory, and took no further action in the matter, although, to my mind, the repairs seemed to be of a decidedly permanent character, at least as much so as the bridge itself. The subject is now again brought to my attention by the questions submitted by the committee on the part of the corporate authorities of the city of Georgetown. Before proceeding to answer the inquiries, I have thought it advisable and interesting, as a matter of history, to examine all the laws, charters, plans, and estimates of the several bridges in the District, and under the control of the government, to ascertain whether any restrictions have been placed by legislative enactments upon the dimensions of their spans, the nature of the material to be used, the different sites for their locations, their approaches, their construction, and more especially whether any laws exist regulating the several conflicting interests of the respective bridges, and the ship channels passing through them; also, to ascertain in whom the power rests to preserve the navigation of both the Potomac and Anacostia Rivers.

The following are the several acts and parts of acts relating to the

matter, which have been compiled from the several volumes of the United States Statutes at Large, published by an order of Congress:

1. "An act authorizing the corporation of Georgetown to make a dam or causeway from Mason's Island to the western shore of the river Potomac," approved January 19, 1805.—(Vol. 1, page 168.)

2. "An act authorizing the erection of a bridge over the river Potomac to Alexander's Island," approved February 5, 1808.—(Vol. 1, page 177.)

The following in brief are some of the features of this act: To be a good and sufficient bridge at least thirty-six feet wide, with a secure railing on each side four feet high and a width of six feet for a way for foot passengers; to have a convenient and sufficient draw, at least thirty feet wide, over the main channel for the passing and repassing of vessels by day and night; a well-constructed and substantial wharf to be erected on piles on each side of the bridge and adjoining or near the said draw, in every respect sufficient for ships and other vessels to lie at securely and free of charge until a suitable opportunity offers for passing; each leaf of the draw to be twenty feet in width instead of thirty-six, the width of the bridge, and to be removed to wherever the channel may pass under the bridge. A draw or passage way of at least fifteen feet in width to be made in said bridge across the other channel, commonly called the Maryland channel, provided the same shall appear necessary on a view and survey thereof. Bridge and wharves to be erected and finished within five years from and after the first day of October, 1808, and should it remain two years out of repair so as to be unsafe for travel, the powers, authority, privilege, emoluments, and immunities granted to the company shall cease and become absolutely forfeited. The toll to be taken at said bridge to be receivable by the said corporation for and during the term of sixty years from the day when the bridge shall be opened for passengers, after which time it shall be the property of the United States.

3. "An act to enable the Georgetown Potomac Bridge Company to levy money for the object of its incorporation," approved February 22, 1811.—(Vol. 1, page 302.)

4. "An act for the relief of the Eastern Branch Bridge Company," approved March 3, 1815.—(Vol. 1, page 302.)

5. "An act for the relief of the Anacostia Bridge Company," approved March 3, 1815.—(Vol. 1, page 302.)

An act of Maryland incorporated this bridge company in 1797.

6. "An act to incorporate a company to build a bridge over the Eastern Branch between Eleventh and Twelfth streets east," approved February 24, 1819.—(Vol. 1, page 334.)

According to the provisions of this act the bridge was to be at least twenty-five feet wide, with a draw thirty feet in width, and to be built in three years. Authority was given to collect tolls; but if the bridge was out of repair for two years so as to be unsafe for traveling, then all powers, privileges, and immunities were forfeited.

7. "An act to alter the bridge and draws across the Potomac from Washington to Alexander's Island," approved May 14, 1836.—(Vol. 1, page 549.)

This act authorizes the corporation of Georgetown to form a draw in the bridge leading from Washington City to Alexandria, across the Potomac River, not less than sixty-six feet in length, nor less than twelve wide; and for defraying the expenses of making said draw, the first appropriation of $6,000 is made. The bridge company are permitted to reduce the width of the bridge to twenty-four feet, leaving four

feet on one side for foot passengers. In making the draw the opposite sides of the wharves are to be curved off in a circular form and the sides of the spaces covered by said draw to be sufficiently and strongly planked up on each side. Authorizes the corporation of Washington to form a draw in said bridge over the eastern channel of said river thirty-five feet wide, for which purpose an appropriation of $2,000 is made.

8. The following is an extract from an act supplementary to an act to incorporate the inhabitants of the city of Washington, and is found in vol. 2, page 215, sec. 3: That the council shall have power to "superintend the health of the city, to preserve the navigation of the Potomac and Anacostia Rivers adjoining the city, to erect, repair, and regulate public wharves, to deepen the docks and various basins," &c.

9. "An act providing for the purchase by the United States of the rights of the Washington Bridge Company, and for the erection of a public bridge on the site thereof," approved July 14, 1832.—(Vol. 4, page 582.)

This act appropriates $20,000 for the purchase of the rights of the Washington Bridge Company, and authorizes the President of the United States to "cause to be erected upon the site of the present bridge a good and sufficient bridge across the river Potomac, of such materials and upon such plan of construction as he shall approve and direct: *Provided*, That the said bridge be so constructed as to have a draw therein suitable for the safe passage of vessels of the largest dimensions, capable of navigating the Potomac River above the said bridge, not less than sixty feet at the least; and also on each side of the said draw, and at a suitable distance therefrom, an arch of sufficient elevation to admit the passage under the same of an ordinary steamboat, which said draw and arch shall be at the Virginia channel in the said river: *And provided further*, That there shall be a similar draw at the Maryland channel, of not less than thirty-five feet, with a similar arch: *And provided also*, That in the selection of the material and in the construction of said draws and arches all practicable attention shall be had to the preservation of the navigation of the said river." By the same act $60,000 dollars is appropriated for the construction of the bridge and works as authorized and directed.

10. "An act in relation to the Potomac Bridge," approved March 2, 1833.—(Vol. 4, page 646.)

This act recites that "so soon as the President of the United States shall decide on a plan for the erection of a bridge over the Potomac River at Washington, on or adjoining the site of the old bridge, the Secretary of the Treasury is hereby required to advertise for contracts, after giving at least thirty days' notice;" and for the construction of the bridge $200,000 is appropriated.

11. "An act to improve the navigation of the Potomac River between Georgetown and Alexandria, and for other purposes," approved March 3, 1833.—(Vol. 4, page 646.)

By this act $150,000 is appropriated to remove obstructions, by enlarging and deepening the channel; to make a turnpike to the District line on the Virginia side; and to purchase the bridge over the Little Falls of the Potomac River. It also provides that the corporation of Georgetown shall pass an ordinance to make said road and bridge free, and to be kept in repair by said corporation forever.

12. "An act authorizing the construction of a bridge across the Potomac and repealing all acts already passed in relation thereto," approved June 30, 1834.—(Vol. 4, page 727.)

By this act all previous acts are repealed, except so much of the

former as authorized the purchase of the right of the Washington Bridge Company. The Secretary of the Treasury is authorized and required to contract for the reconstruction, on the site of the present bridge, of a bridge on the plan of that originally constructed there by the Washington Bridge Company: *Provided*, That the draw at the southern channel of the river be not less than sixty-six feet, and at the northern channel not less than thirty-five feet; that a space or spaces not exceeding in all one thousand six hundred and sixty feet of the shoal or shoals, over which the present bridge passes, may be filled up by a solid embankment, in parts if convenient, of earth obtained by dredging the river channel. A sum, not to be exceeded, of $130,000 is appropriated.

13. "An act to amend an act entitled 'An act authorizing the construction of a bridge across the Potomac and repealing the acts already passed in relation thereto,'" approved March 3, 1835.—(Vol. 4, page 773.)

Amended so far as to authorize a connection by a solid embankment across the middle, commonly called the south channel, of the river Potomac, of the two embankments now constructing on the shoals of the said river, and the addition of the several improvements upon the plan of the said bridge, contemplated in the contract for the construction thereof, which are recommended in the letter of the engineer superintending the said work to the Secretary of the Treasury bearing date December 1, 1834, and transmitted to the House of Representatives on the eighth day of said month. The said improvement shall not cause the entire cost of said bridge to exceed in amount the sum of $130,000 already appropriated.

14. "A resolution authorizing the repair of the bridge across the river Potomac at Washington," approved June 7, 1836.—(Vol. 5, page 132.)

That the Secretary of the Treasury be authorized to have all the repairs made to the bridge which have become necessary from the late flood, and that the expenses of said repairs be paid out of the money heretofore appropriated for the erection of said bridge, and which is now in the treasury unexpended.

15. "A resolution to apply the unexpended balance of the appropriation for the Potomac bridge to the improvement of Maryland avenue leading thereto, and for other purposes," approved July 1, 1836.—(Vol. 5, page 134.)

This act provides that the money appropriated be applied, under the direction of the Commissioner of Public Buildings, towards the graduation, graveling, and planting of the Maryland avenue, &c.; that it shall be the duty of the Commissioner of Public Buildings to attend to the draws, cause the bridge to be properly lighted, to guard against wanton injuries and obstructions, and to preserve a due police on and near it, so as to insure the safety of passengers and of the public property; that said commissioner shall receive for his services the yearly compensation of three hundred dollars, and be authorized to employ three assistants at a compensation not exceeding one dollar and a half a day.

16. "An act to extend the jurisdiction of the corporation of the city of Washington over the Potomac Bridge," approved March 3, 1839.—(Vol. 5, page 364.)

17. "An act to provide for repairing the Potomac Bridge," approved September 11, 1841.—(Vol. 5, page 462.)

This act appropriates the sum of $15,800, in addition to the sum heretofore appropriated, for the repairs of the bridge. It also enacts that the said sum shall be expended under the direction of the Secretary of War, in the following manner, to-wit: He shall designate

some competent officer of the engineer corps to draw plans, and make specifications of the work to be performed, and estimates of the cost or value thereof, which shall not exceed the sum of forty-five thousand eight hundred and six dollars; the officer thus selected shall lay his plans, specifications, and estimates before the Secretary of War for his approval, and the said Secretary shall thereupon cause the work to be constructed upon the plan most approved by him, under the immediate superintendence of some competent officer of either engineer corps, who shall make all necessary contracts for materials and labor, and cause the work to be constructed in the best and most substantial manner, within the estimates and according to the plan approved by the Secretary of War, and under the orders and general direction of said Secretary, who will from time to time cause such advances of the amounts for this object appropriated as he may deem necessary and proper. That the timbers, or such of them as the superintending engineer may think fit, shall be mineralized, &c., &c., &c.

18. "An act to extend the jurisdiction of the corporation of Georgetown," approved July 27, 1842.—(Vol. 5, page 497.) This act extends the jurisdiction of the corporation of Georgetown so as to include the bridge lately constructed by said corporation across the river Potomac at the Little Falls, and the site of said bridge and premises appertaining to said site; and that so often and as long as said bridge shall hereafter from any cause be impassable, it shall and may be lawful for the proprietors of land on both sides of the said river, through which the ferry road to connect with the Little Falls Bridge turnpike must necessarily pass, and they are hereby authorized and empowered to establish and keep a ferry, &c.

19. "An act making appropriations for the civil service for the year ending June 30, 1849, and for other purposes," approved August 12, 1848.—(Vol. 9, page 284.) * * * * * * * *
For the purchase of one or both of the bridges over the Eastern Branch, at a valuation to be made in such manner as the Secretary of the Treasury may direct, a sum not exceeding thirty thousand dollars, when purchased to be free of toll. For compensation and contingent expenses of the auxiliary guard, $6,775.

20. "An act making appropriations for certain civil expenses of the government for the year ending June 30, 1857," approved August 18, 1856.—(Vol. 11, page 117.)

For repairs of Potomac Navy Yard and Upper bridges, $11,000, and with a view to the construction of a new and substantial bridge across the Potomac, the Secretary of the Interior be, and he is hereby, authorized to cause drawings and estimates of an iron suspension bridge, and also for a stone arched bridge, to be prepared and submitted to Congress at its next session; and with a future view of enabling Congress to select the most eligible site for said bridge, the Secretary aforesaid is instructed to cause drawings and estimates to be prepared at or near the site of the present Potomac bridge; another at or near a place known as the "Three Sisters," and another at such intermediate point as may be deemed most eligible.

21. "An act to extend the jurisdiction of the corporation of the city of Washington over the Lower Eastern Branch or Navy Yard bridge, and for other purposes," approved Aug. 18, 1856.—(Vol. 11, page 117.)

22. "An act making appropriations for certain civil expenses of the government for the year ending 30th June, 1858," approved March 3, 1857.—(Vol. 11, page 221.)

For repairs of the Potomac, Navy Yard, and Upper bridges, $6,000.

23. "An act making appropriations for sundry civil expenses of the government for the year ending June 30, 1859," approved June 12, 1858.—(Vol. 11, page 319.)

For the repairs of the Potomac, Navy Yard, and Upper bridges, $6,000. To pay the residue of the salary of the engineer for constructing the bridge across the Potomac at Little Falls, $2,589 67, and for painting the hand rails and iron work of said bridge $400. And the bridge is hereby placed under the protection of Georgetown, with power to regulate the speed of travel and the passage of droves of cattle over the same, but no toll shall be charged.

24. "An act making appropriations for sundry civil expenses of the government for the year ending the 30th of June, 1860," approved March 3, 1859.—(Vol. 11, page 425.)

For the repairs of the Long bridge over the Potomac River at Washington, $5,000, to be expended under the direction of the Commissioner of Public Buildings.

25. "An act to reimburse the corporation of Georgetown, in the District of Columbia, a sum of money advanced toward the construction of the Little Falls bridge," approved June 12, 1860.—(Vol. 12, page 29.)

$4,600 is appropriated.

26. "An act making appropriations for sundry civil expenses of the government for the year ending June 30, 1861," approved June 25, 1860.—(Vol. 12, page 29.)

For the repairs of the Potomac, Navy Yard, and Upper bridges, $6,000.

27. "An act making appropriations for sundry civil expenses of the government for the year ending June 30, 1862, and appropriations of arrearages for the year ending June 30, 1861," approved July 24, 1861.—(Vol. 12, page 271.)

For repairs of the Potomac, Navy Yard, and Upper bridges and the roads appurtenant thereto, $10,000.

28. "An act to provide for the repairs of the Long bridge across the Potomac River," approved August 6, 1861.—(Vol. 12, page 271.)

That the sum of twenty thousand dollars be, and is hereby, appropriated for the repairs of the present Long bridge across the Potomac River.

29. "An act making appropriations for sundry civil expenses of the government for the year ending 30th of June, 1863, and additional appropriations for the year ending 30th of June, 1862," approved July 11, 1862.—(Vol. 12, page 533.)

For repairs of Potomac, Navy Yard, and Upper bridges and the road appurtenant thereto, $6,000.

30. "An act making appropriations for sundry civil expenses of the government for the year ending June 30, 1864, and for the year ending June 30, 1863," approved March 3, 1863.—(Vol. 12, page 744.)

For the repairs of the Potomac, Navy Yard, and Upper bridges, and the roads appurtenant thereto, and to repair the house occupied by the bridge keeper at the navy yard, and to erect a wing wall to protect the same, $11,585.

31. "An act to extend the charter of the Alexandria and Washington Railroad Company, and for other purposes," approved March 3, 1863.—(Vol. 12, page 805.)

This act authorizes the Washington and Alexandria Railroad Company to extend their railroad from the south side of the Potomac River across said river, to and along Maryland avenue to the Capitol grounds, &c., and empowers the company "to make such additional structure or passage-way along either side of the Potomac bridge as may render the

same safe for public use, and so as not to hinder the general use of said bridge for ordinary travel, which shall be ascertained by one or more experienced civil engineers, who shall report, by proper surveys and estimates, to the Secretary of the Interior for his approval; the whole cost of which survey and construction of said additional bridge for the purposes aforesaid to be paid by the said company. And the said company shall construct such draws as shall correspond with those now in use on the said bridge, and of such model as shall be determined by the Secretary of the Interior, and which shall afford reasonable facilities for navigation on the Potomac River."

32. "An act making appropriations for sundry civil expenses of the government for the year ending the 30th of June, 1862, and for other purposes," approved July 2, 1864.—(Vol. 13, page 344.)

For repairs of Potomac and Upper bridges, $6,000; for repairs of Navy Yard bridge, $25,000; for repairs of Little Falls bridge, $250.

33. "An act making appropriations for sundry civil expenses of the government for the year ending June 30, 1866, and additional appropriations for the current fiscal year," approved March 3, 1865.—(Vol. 13, page 445.)

For repairs of the Navy Yard bridge, to enable the Commissioner of Public Buildings to erect a new draw, $1,000.

34. "An act making additional appropriations, and to supply the deficiency in the appropriations for sundry civil expenses of the government."—(Vol. 14, page 14.)

For repairs of the Potomac and Upper bridges, $6,000.

35. "An act making appropriations for sundry civil expenses of the government for the year ending June 30, 1867, and for other purposes," approved July 28, 1866.—(Vol. 14, page 310.)

To enable the Commissioner of Public Buildings to put in thorough repair the bridge across the Potomac at Little Falls, in accordance with the estimates of the engineer, $2,410. For casual repairs of the Potomac Navy Yard, and Upper bridges, $6,000. For erecting a new draw in Navy Yard bridge, $5,000.

36. "Joint resolution making an appropriation for the repairs of the Potomac bridge," approved June 18, 1866.—(Vol. 14, page 360.)

That the sum of $10,000 be and the same is hereby appropriated to enable the Commissioner of Public Buildings to place the Potomac bridge in such repair as to render it permanently passable, the work to be done immediately after the approval of this joint resolution.

37. "An act making appropriations for sundry civil expenses of the government for the year ending June 30, 1868, and for other purposes," approved March 2, 1867.—(Vol. 14, page 457.)

For casual repairs of the Navy Yard and Upper bridges, $6,000.

38. "An act making appropriations to supply deficiencies in the appropriations for the service of the government for the fiscal year ending June 30, 1867, and for other purposes," approved March 2, 1867.—(Vol. 14, page 468.)

To pay deficiencies and keep in repair the bridge at or near the Little Falls, Potomac River, $3,350.

39. "An act making appropriations to supply deficiencies in the appropriations for contingent expenses of the Senate of the United States for the fiscal year ending June 30, 1867, and for other purposes," approved March 29, 1867.

For the repairs of the Long bridge, District of Columbia, to be expended under the direction of the Secretary of War, $15,000.

40. "An act making appropriations for sundry civil expenses of the government for the year ending June 30, 1869," approved July 20, 1868.

For casual repairs of the Navy Yard and Upper bridges, $3,000. For repairs and taking care of the bridge, at or near the Little Falls of the Potomac River, $26,000. For repairs of the Long bridge, $15,000.

41. "An act making appropriations for sundry civil expenses of the government for the year ending June 30, 1870, and for other purposes," approved March 3, 1869.

For repairs of the Long bridge, $5,000. For casual repairs of the Navy Yard and Upper bridges, $3,000. For repairs and taking care of the bridge, at or near the Little Falls, $2,000.

It is to be regretted that but few of the reports, plans, and estimates of the different bridges are now available, and it would require very diligent search to find them among the archives of the several departments having at different times the control of the building and repair of these structures; but in their absence, several interesting facts concerning those works, aside from the various amounts appropriated and expended upon them, are furnished by the statutes just quoted. The first Potomac bridge was built in 1809 by a company on the site of the present one, and remained in uninterrupted use until 1831, when a large part was carried away by a very great freshet, and masses of floating ice. An act of 1830 makes the first appropriation and directs certain alterations to be made, consisting in lengthening the draws, planking the sides of the spaces covered by them, and that the opposite sides of the wharves above and below the bridge should be curved off in a circular form. By an act approved in 1832, and subsequently amended in 1834 and 1835, the bridge was purchased by the government of the United States, and the report of the engineer, dated December 30, 1835, states that it "has been completely finished, according to the terms of the contract, in all its points; and since the 28th of October last, has been thrown open to the general travel." The bridge was first rendered passable on the 1st of October, on which day "the President and cabinet crossed it on foot and returned in carriages. The bridge then constructed was substantially the same as that which now exists; that is, the part crossing the shoal was made a causeway and connected with the shores by wooden bridges resting on piers. For a few years the bridge escaped without damage, when, in 1840, a portion was again destroyed by ice. Without exact data it is impossible to enumerate all of the different occasions upon which it was injured; but it is known that such was the case, and very severely so, in 1856, 1860, 1863, 1866, and 1867. In several instances many spans were carried away and travel suspended for many months at a time. It is also ascertained with great certainty that, in a majority of the cases, the accidents occurred to those portions built on piles where the spans are short and low. Toward the Virginia shore, where the bridge rests on piers with a clear water-way of over one hundred feet between them, through which the floating matter, drift, and ice may freely pass, no injuries of a serious nature have been sustained, at least not from that particular cause. The railroad bridge, which is owned by the Washington, Alexandria and Georgetown Railroad Company, was built in 1863 and 1864, and is about seventy-five feet below and parallel to the Long bridge. The repairs being made to strengthen the southern section of the former, that portion between the span over the main channel and the Virginia shore, and against the plan of which the remonstrances were made and the attention of the

receiver of the road called by letter previously mentioned, are immediately below the spans of the Long Bridge, which are referred to above. The repairs consisting in driving intermediate piles between the old piers, and thus subdividing the spans into sections of from eleven to eighteen feet, will most certainly, in the opinion of any disinterested person, cause a formidable obstruction, and be the means of greatly impeding the flow of the drift and ice, which, owing to the greater width of the spans, can safely pass the upper bridge. The material brought down will become packed against these piles, partially if not completely forming a dam, and thereby closing up the space between the two bridges; the only outlet would then be by the channel way through the draws. Should the coming winter be even moderately severe, judging from past experience and natural cause and effect, the destruction of those portions of the two bridges will prove inevitable. The railroad authorities still continue the strengthening of their bridge by driving piles, when other plans might be easily substituted; previous to the commencement of the work the six spaces between the Virginia shore and the Georgetown channel were from one hundred to one hundred and twenty-five feet in length, resting on wooden piers or cribs, and were amply efficient for all purposes. The original design of the bridge is being very considerably altered, transforming the truss bridge into one on piles. The current of the river at this point becomes very rapid, and at the breaking up of the winter large bodies of ice come down with great force, while in the spring the larger portion of the drift from the upper Potomac is carried with increased velocity through the Virginia or Georgetown channel. "The great depth of this channel and the velocities of the current there during floods are sufficient causes against the erection of many piers." In some portions of the Long bridge, where piles have been driven at from twenty-two to thirty feet apart, the ice and drift accumulate above it for upward of forty and fifty feet, and so close to the structure as to bear the weight of several men. These facts alone should prove a satisfactory reason why no additional obstructions, especially when so unnecessary, and while other plans could be successfully adopted, be allowed to be placed in the bed of the river, and competent authority should compel the company to desist from further encroachments upon the channel way.

The committee on the part of the corporate authorities of the city of Georgetown have been advised that certain repairs, those previously referred to, were being made to the railroad bridge over the Potomac River, which may have the effect to impair and destroy the channel of the river so far as the port of Georgetown is concerned, and are desirous of ascertaining the probable extent of such damage and injury. In the act providing for the purchase by the United States of the rights of the Washington Bridge Company, and for the erection of a public bridge on the site thereof, and which was approved July 14, 1832, appears the clause "that in the selection of materials, and in the construction of said bridge, draws and arches, all practicable attention shall be paid to the preservation of the navigation of the said river." The law applying to the construction of the one bridge should certainly be enforced in the building or repairing of the other structure, the more especially as Congress the very following year appropriated one hundred and fifty thousand dollars "to remove obstructions by enlarging and deepening the channel," and for other purposes; when such large expenditures are made to improve a channel, it certainly becomes those most interested that "every attention shall be had to the preservation of the navigation." The care of

this preservation by "An act to alter the bridge and draw across the Potomac from Washington to Alexander's Island, approved May 14, 1850," is given to the council. Section third of the act reads "that the council shall have power to * * * * to superintend the health of the city, to preserve the navigation of the Potomac and Anacostia Rivers adjoining the city; to erect, repair, and regulate wharves; to deepen the docks and basins, &c."

The law thereby also appoints the proper persons to watch over and preserve the navigation.

The question now arises whether the certain repairs being made on the railroad bridge will have the effect to destroy the channel of the river so far as the port of Georgetown is concerned. After a careful study and consideration, it is my opinion that the obstructions formed by the piles used in the repair will eventually effect, and it may be, very seriously, the channel of the river. A very distinguished engineer writes that "every obstruction temporarily placed in the way of the current, every attempt to guard one point by any artificial means, inevitably produces some corresponding change at another which can seldom be foreseen, and for which the remedy applied may be but a new cause of harm."

He continues to say that "no obstruction should be placed to the free ingress of the tides through all the channels." The many able reports written in years past generally agree upon the plan of removing all obstructions, even to the Long Bridge causeway. Colonel Abert, chief of the corps of topographical engineers, reports that this causeway has aided, in all the difficulties concerning the channels, the tendency to shoaling in all of them. He also states, "that the causway of the Long bridge is not the result of the plan of any United States engineer officer, but was adopted against the advice of all who were consulted upon that occasion; but the plan being made a positive direction of law, it had to be pursued in the construction of the bridge."

The causeway has proven a very great evil, but the injury done should not be accelerated by further obstructing the channel way.

Lieutenant Colonel Kearney, of the same corps, in his report on the Potomac bridge, writes as follows: "From the natural bed of the river, yielding as it does under the action of a very slight force, it must be apparent that the depth and course of the channels are not very constant, and accordingly our own observation made upon it united with tradition to confirm the opinion of extreme variableness. It is near the middle channel that, in former days, the river had worn for itself the deepest passage. We have penetrated the alluvial deposit to a depth of forty feet at that place. The action of a more rapid current than that which usually flows near the city shore, and one also which struck it very obliquely, is evinced by the bluff shores south of the Tiber. These observations are necessary to demonstrate the extreme care that should be observed in securing the foundations of the bridge, the requisite stability, and the caution with which we should avoid every unnecessary interruption of the current." From the several reports made by others who have examined, the general opinion is that all obstructions, whether they be of causeways, piles, or any other kind, excepting only those that are absolutely necessary for the support of the bridges, should be removed, so as not to interfere with the current of the river. The Potomac being a tidal river, the reason for doing so becomes still greater; for the same cause, as well as those above stated, all shoals should be deepened, and such

parts of the different channels, both above and below the bridges, as now tend to arrest the ascent and descent of the tidal wave, should be widened. So important has the improvement of tidal rivers become in Great Britain, that commissioners have been appointed to investigate the whole subject, and to inquire what measures it may be convenient to adopt for the general improvement of the harbors and rivers of the United Kingdom. The most stringent legislative measures were recommended by the tidal harbor's commission for the conservancy of the harbors and rivers.

I had the honor, general, on the 30th of April, 1868, to submit you a report on the examination or survey of the Potomac River, a copy of which is contained in the pamphlet marked C, pages 28 to 39, accompanying this paper. In that report the whole matter of the improvement of the channel is discussed. The following are some extracts from the same: "In anticipation of such improvements legal measures should be taken for remedying all existing injuries to the channels, for the conservation of the shores and harbors, for preventing further encroachments in the construction of such wharves as may produce any damaging effects. Every encroachment should be received with the greatest jealousy." In speaking of the removal of the causeway, the same report says that, "whatever opinion may be held or expressed by others in regard to the obstruction or encroachment in the river, in consequence of the building of the causeway of the Long bridge, it has been clearly demonstrated to me that there is no doubt that the structure is very injurious to the Washington channel, and that the section referred to should, therefore, be removed, and replaced by either an arched bridge or one of iron or wood. Those acquainted with the river have pointed out a marked increase, during the last ten years, in the dimensions of the flats, and consequent diminution in the depth and width of the channel. While the causeway obstructs to a considerable degree the water coming down from the interior of the country, it also partially prevents the tide water from coming up; it therefore interrupts that continual scour which should result from the force of the one and the flowing and ebbing of the other; the tides should have a perpetual and unrestricted current." The great object to be kept in view, in carrying into effect the improvement of the navigation of a tidal river, is the free admission of the greatest possible quantity of water from the sea, as reliance must be chiefly placed on the scour produced by the tide, and not on the current of the fresh water, as the chief agent in keeping open the navigable channel of the river.

Many celebrated engineers have concurred in the above opinion; and this being admitted, "it is manifest that all obstructions to the tidal flow upward should be removed;" such as shoals and bars, or dams and dikes, or any other cause of obstruction.

The same reason that applies to a greater evil will apply to a lesser one. It would be impossible to ascertain the exact time or estimate the extent of such damage or injury, as so many unforeseen natural as well as artificial causes enter into the calculation. The only remedy is to remove as soon as possible the cause, if well established, of the evil now complained of, and in future to prevent its recurrence. The navigation of the Potomac is not a thing of to-day, but must live in the future, to aid in the promotion of the enterprise and enlightenment of a more advanced civilization and culture; its channels should be preserved and guarded with the utmost care against all encroachments. The problem has always been considered a most uncertain one, but infi-

nitely more important and difficult than the spanning of a stream by a bridge. The latter should and can always be built to accomplish its laudable purpose without interfering with the navigation of the river it crosses.

I am, general, very respectfully, your obedient servant,

N. MICHLER,
Major of Engineers, Brevet Brigadier General U. S. A.

Brevet Major General A. A. HUMPHREYS,
Chief of Engineers, Washington, D. C.

W 3.

In compliance with Engineer Order No. 10, dated Washington, February 21, 1867, the following officers of the Corps of Engineers, viz: Major N. Michler, brevet brigadier general United States Army; Major W. P. Craighill, brevet lieutenant colonel United States Army; Captain W. R. King, brevet major United States Army, comprising a board of engineers detailed "to examine the model of an improved canal and ship lock constructed by Mr. Martin Bishop, of Ohio," beg leave to submit the following report.

In addition, the board is instructed to consider the "value of the invention in facilitating commercial affairs of the country, and more especially its adaptation to aiding in the construction of a ship canal through the city of Washington."

In pursuance of the order the board met, all the members being present, and an invitation was extended to Mr. Bishop to meet and confer with them. After an examination of the model, and a detailed explanation by the inventor, the board adjourned in order to afford the latter an opportunity to procure drawings of the patent, and prepare estimates of the probable cost of the construction of a lock of the proposed kind and of suitable dimensions for some of the canals now in general use. Owing to the subsequent and long-protracted illness of Mr. Bishop he was unable to furnish these papers for several months; this detention, in connection with pressure of other duties upon the time of the different members of the board, caused delay in preparing this report.

The following description of the invention, with the accompanying isometrical drawings of the plan, sections, and moving apparatus, prepared by Mr. John de la Camp, is submitted for consideration.

Its leading feature depends on the construction and mode of operating the lock-gates. The novel arrangement of the gates A, instead of turning on vertical axes, as in the old system, consists in moving them up and down on horizontal axes B; for that purpose, each one is composed of a series of radiating arms C, of the shape of a sextant, which may be of cast-iron sheathed with copper, or galvanized; these move up and down on a horizontal axis, and when the gate is open they rest in grooves D, formed in the bottom of the chamber, or tail bay, by partitions E, of masonry, iron, or timber, whatever the material used may be. A strong planking, forming the face of the gate, is fastened to the inner periphery of the arms; the shape of the gate is that of a part of a cylinder, the bases of the latter fitting into recesses G in the chamber, or tail walls, and are made to fit tightly. The levers H, when turned, raise and close the gate to, the water in the lock pressing the latter against the wall, and thereby closing the joints. The hoisting apparatus is placed in recesses in the walls on each side of the gate, and consists of vertical screws I, along

which the traveling burrs K are made to move up and down between guides L; the screws are worked by means of windlasses M, on top of the chamber walls. To these traveling burrs are attached the upper ends of two pitmans N; the lower ends of these are connected with a beam O running across and underneath the peripherical part of the gate from one wall to the other. By this arrangement the weight of the gate is transferred to the traveling burr, which, by moving up and down, lifts the gate up or lowers it on its horizontal axis. The weight of the gate is partly overcome by a counterpoise weight P which is attached to the beam O under the gate by means of a chain or rope carried over a roller Q, and thereby acts upward. The filling and emptying of the chamber are accomplished by two rows of wicket R which run across the chamber directly in front of the face of the gate; each of them moves on a horizontal axis S extending across the chamber. When turned, so as to assume a vertical position, four rows of chutes (slots) are formed or opened by which the water can escape into channels U made in the partitions between the arms of the gate, and through them carried off into the lower chamber or into the basin below the lock. When revolved on the axis so that they attain nearly a horizontal position, the wickets again close the chutes by the pressing or fitting together of corresponding smooth surfaces. The movement of the wickets is effected by a screw arrangement similar to that used for hoisting the gates, the difference consisting in the pitman V being attached at their lower ends to two cranks W, one at the axis of each of the two rows; when closed the cranks will be in a horizontal, and when open in a vertical position. As the gate, when open, is entirely below the bottom of the canal, a recess is made to receive it. The object which the inventor claims to have attained by his proposed plan of improvement is, to have a perfect lock when the gate is up; and when down, an open channel for the water, it being then entirely submerged. The principal advantage to be gained by this plan will be found in its application to very large locks, which, under the present system of constructing the gates, labor under the difficulty caused by the enormous weight of the latter; a great amount of either physical or mechanical force is exerted to operate them successfully, either of which has a tendency to cause very considerable and constant wear and tear of the gates themselves, as well as of the side walls and bottom of the chamber. By the new plan under examination the power to be employed in raising and lowering the gate of a lock of any capacity will be exactly in proportion to its dimensions; whereas in the old one, as the gates will have to be built more substantially and consequently heavier as a lock becomes enlarged, and thereby creating a constantly increasing ratio of weight to be acted upon, the force to be applied in opening and shutting them will be much greater than in proportion to the size of the lock; this will cause, in consequence of the necessarily disproportionate increase of friction, a much more than proportionately increased expenditure of labor. Every new invention in its incipient state may be susceptible of many improvements, and, while enumerating the advantages of the one being examined, it may not be amiss to point out its defects, and submit some suggestions in reference to their avoidance.

In the first place, the screw arrangement, forming part of the hoisting apparatus, and used in the machinery for turning the wickets, will be found to labor under a great many peculiar disadvantages, of which the following may be mentioned: The screws, which may be of iron with the spiral-shaped worm of steel, will, together with the machinery attached to it, be for the greater part of the time under water, and con-

sequently liable to corrode very rapidly; the traveling burr K shown on the drawing being of a somewhat complicated structure, and intended to move quite smoothly between the guides by means of friction rollers X, will soon be prevented from doing so by rust. Another cause of constant wear on the screw will be the heavy pressure upon it with which the burr, supporting the weight of the gate, acts as it moves up and down along it, notwithstanding the operation of the counterpoise. Any necessary repair of the machinery in consequence of the greater portion of the mechanism being inclosed in the walls of the chamber and partly under water, will be the cause of very great delay to navigation; the water will then have to be pumped out of the lock in order to reach the works. Journals, couplings, friction rollers, and other details, would apparently render the cost of the material very expensive. Another disadvantage in respect to the screw will be the difficulty in obtaining room on the top of the walls for revolving it by means of walking the lever around its axis. The application of a rack and pinion, proposed by the inventor, to replace the screw for hoisting the gate, exhibited on the drawing, will also possess the same objection, in common with the screw, of being under water; it could only be moved by a derrick on top of the wall in connection with the rack and pinion, and even then would be somewhat complicated. In place of either screw or rack and friction movement a wire rope or chain might be attached to the beam underneath the gate, and wound up, or the reverse, for the purpose of raising or lowering the gate by means of capstans located on the walls; this arrangement would dispense with all the machinery under water. Another objection to the present plan is the mechanical arrangement by screws to open and close the wickets, besides the difficulty, next to an impossibility, of keeping the joints at the journals sufficiently tight. Another contrivance might be adopted for effecting this object. Two continuous valves stretching from one wall across to the other, might answer the purpose.

Each is hoisted and lowered by a lever, one similar to those used in the moving apparatus of railroad switches, which acts upon one end of a quadrant, the other end of the latter being attached to the valves by a connecting rod. This arrangement would allow of a larger space for the water to flow through than that of the wickets. It is due the inventor, and the statement may properly appear at this stage of the report, to mention that the time which he claims for filling and emptying the lock, as given in his circular submitted to the board, is not in conformity with the space allotted for the water to flow through, as shown in the drawing and exhibited in the model. The openings and the wickets, he alleges, must be made so as to give eighteen inches clear opening on each of the wickets, which is the size of similar arrangements at existing locks. Let his example be taken, a lock two hundred feet in length by thirty-four feet in width with ten feet lift, which would contain sixty-eight thousand cubic feet of water. The velocity of the water flowing out under the head of ten feet, is twenty-five feet per second, and the mean velocity, during the time of escape, would be eighteen feet per second. With eighteen inches clear opening on each side of each wicket, the entire space through which the water flows is one hundred and eighty square feet; by reason of the contraction of water through apertures, six-tenths only of this area can be taken into consideration. The necessary calculations show that the whole amount of water, sixty-eight thousand cubic feet, would have to pass through one hundred and eight square feet, and, at a mean rate of eighteen feet per second, some thirty-five seconds would be consumed in its passage. This space of time may

seem to the cautious engineer so very brief as to endanger the safety of the boats in the chamber; the regularity of the escape throughout the entire width of the chamber, and the fact that its rapidity can be regulated by a proper manipulation of the wickets, will overcome any objection of the kind. The escape through the chutes, reaching from one wall to the other, will certainly be much more regular than that through the apertures or valves in the gates or chambers of existing locks. The greater capacity of the wickets on the new plan will become particularly useful, when, as the inventor suggests in his circular, instead of a lock-chamber capable of containing only one or two boats, a large pool with water-tight paved slopes is established for harboring a larger number of boats; all of them can then be brought to the next level at the same time, and no longer period will be required than is now consumed in passing one boat through a lock constructed on the old plan. The necessity for any alteration in the construction of the radiating arms would exhibit itself in practice; the central braces should reach all through from the periphery to the center, in order to transfer the whole pressure to the strongest point. The flange on the upper side, which is intended to close off the water, might be omitted, as it is not possible or necessary to keep the water from flowing through between the partitions; in addition, its greater width, on account of the greater quantity of water to be displaced, will increase the effort required to hoist the gate. A few of the practical difficulties which may arise in the use of Mr. Bishop's invention may be here mentioned: There is a liability to "jam," either by boats attempting to pass over the gate before it is fully opened, or by drift-wood, gravel, or other bodies being forced by the water into the joints between the gates and walls or floor of the lock. Again, a deposit may form in the recess made for the receptacle of the gate when opened, which would prevent the gate from being lowered sufficiently to allow the boats to pass. It is proposed to clear this space by opening the wicket and allowing a stream of water to pass down the chute and out towards the horizontal axis of the gate, but this stream will be deflected toward the line of least resistance or the surface of the water, and will consequently come up in a curved line at some intermediate point between the axis and the face of the gate, leaving a considerable portion undisturbed. Again, since the space occupied by the axis, arms, and face of the gate is not available for boats, the length of the lock must be increased by at least the length of one of the arms, or about twice the lift of the lock. This will add to the expense of construction as well as to the volume of water which must be let in or out at each passage of a boat through it. The precise magnitude of these objections, as compared with the advantages to be gained, can only be determined by actual experiments. Since the pressure of a fluid always acts in a direction normal to the surface pressed, it is evident from the properties of the cylinder that the resultant pressure in this case must pass through the axis of the gate, and, the weight of the latter being counterpoised, as already stated, there can be no force tending to open or close it, and consequently the power applied to raise or lower the gate will (theoretically) meet with no resistance but from the friction of the axis and the screw or other machinery, by means of which the power is transmitted. This may be regarded as a beautiful application of the principle of hydrostatics, and the inventor of the new lock, Mr. Bishop, deserves great credit for the zeal and perseverance with which he has advocated its adoption for more than twenty years. The difference between his arrangement and that of the ordinary lock will be readily understood from an examination of, and comparison between, the two drawings which ac-

company this report. A description of the one has already been minutely given, and one or two points in reference to the other will be but briefly referred to in this report; an elaborate description is unnecessary, as the plan is already well known to all. On the sketch, A B represents a horizontal section of one leaf of the gate swinging about a vertical axis at A, as represented by the dotted curve B C, and meeting a similar leaf at B. The line of the resultant pressure of the water is represented by an arrow; it evidently acts as a dead weight to keep the gates closed until the water is brought to the same level on both sides of them, and this latter is accomplished by opening small valve gates, which are placed for the purpose either in the walls of the chamber of the lock, or in the leaves of the large gates. The time of passing a given lock, therefore, depends chiefly upon the size, number, and facilities for opening the valve gates or wickets; these conditions have been, or at least may be, so regulated that any lock chamber may be filled or emptied as rapidly as is consistent with the safety of the boats and lock, in consequence of the plunging and boiling motion of the water. Since these latter effects would be very nearly the same in Mr. Bishop's lock, the only advantage in point of celerity, which is the first and most important condition claimed for this invention, is that the gate in this case begins to move as soon as the filling or emptying of the lock is commenced, while the ordinary gate can only be moved after the filling or emptying is completed. The gain in time is, therefore, principally that required to move one of the ordinary gates through an arc of about sixty degrees. Another advantage claimed is, that by dispensing with miter sills an additional foot of water is gained. Whether or not the top of the miter sills in the ordinary locks may not be placed on a level with the bottom of the canal, is a question which will decide if a greater depth of water cannot be made available by dispensing with them.

The proposition to submerge locks in the channels of rivers during floods is, at least, of questionable feasibility. Although the gates are below the level of the bottom of the lock, and the walls only remain above that level, it is more than probable that the torrent of water, ice, drift-wood, sand, and other moving bodies would render the lock unserviceable for some time after the subsidence of the flood, even should the walls themselves be not undermined and destroyed altogether by the force of the same destructive agents. The velocity of such a torrent, which would be that due to a fall of ten feet in three hundred, supposing these numbers to represent the "lift and length" of the lock respectively, would be immense; let to this be added the weight of water pouring over the side walls of the chamber and bays, (which must take place; otherwise, why open the gates at all?) thereby causing great damage to the masonry and machinery, and the combination will be found to be one of the most powerful agencies with which the engineer is called to contend. It is also claimed that another advantage is gained in this improvement by being able to construct these locks in the most durable manner, such as the use of cast-iron gates, but it will be found that in the ordinary canal lock, as at present constructed, the best available material is employed, the gates in some cases being of cast iron, or, still better, of corrugated iron. Another advantage that might be claimed is, since there is no pressure upon the walls of the lock due to the side thrust of the gate as in the case of the ordinary lock-gate, that the thickness, and consequently the cost of the walls, may be very much reduced. It is evident from the construction of the one, that the thrust is quite considerable, since the pressure of the water is resisted by the truss A B A, composed of the gates themselves; this, however, may be easily

overcome by placing small buttresses opposite the points pressed upon, as represented by the dotted lines in the drawing; when thus counteracted, which would but slightly increase the expense of construction, the thrust would be of considerable advantage in keeping the joints between the gates and those between the gates and walls of the lock water-tight. The remaining portions of the walls would have the same pressure to sustain in the case of either kind of lock, and therefore no reduction in their dimensions could be made in favor of either of the plans. Estimates A B C are herewith appended of the probable cost of locks of equal size, the one built on the old plan, and the others upon the one submitted by Mr. Bishop. A is the copy of an estimate contained in the annual report for the year 1864, of the State engineer and surveyor on the canals of New York; B is an estimate of a lock of the same size constructed with the proposed new improvements; and C is an estimate of a lock containing water-tight paved slopes in the main chamber instead of vertical walls. The two last have been prepared by Mr. Bishop. Upon a careful examination, neither of them exhibits any marked errors, and a comparison of the costs of the two plans is very decidedly in favor of the invention submitted to the board for its investigation. The nature of the contrivance and the advantages claimed, many of which have been referred to and discussed in the preceding part of this report, are chiefly set forth in a circular, of which the following is a copy, issued by Mr. Bishop to different boards of commerce and trade:

Among the various occurrences of the present period of time there is about to be offered for use to the commercial world an improvement to aid in facilitating and economizing in that class of business to such an extent as to revolutionize nearly all the present modes of transporting on rivers and canals. The present canal locks may be rebuilt with good materials so as to form pools of three hundred feet by seventy feet, and place the gates at that distance apart, of such width as will pass two boats side by side; then by one propeller five other boats may be towed in a fleet, and the whole fleet passed through the locks in less time than single boats are passed now by the old plan. The plan to be adopted will enable the public to dispense with animal power altogether on canals, and in the improvement of rivers will supersede the necessity of side-cuts on the shore; consequently steam-power will be brought more into universal use.

All of the above ideas are based on an unrivaled improvement in canals and river ship locks. The great improvement consists in filling and discharging the water through the locks in an extraordinary short time, dispensing with miter-sills, giving one foot more of water to an increased size of boats, and operating large gates in wide channeled locks, with as much ease as in narrow ones, with very little difference in time, as w de gates vent water with an equal proportion in quantity to the variety of sizes.

In rivers, the locks may be completely submerged in floods without the least risk of damage to them; and more, the gates are so disposed of, in case of floods, as to permit the water to flow freely through the whole size of the lock, thereby keeping a clear channel without any other labor; and whenever it is desired to use the lock after the water recedes to the top of the walls, the gates are replaced in the usual position with all the celerity imaginable, and directly stopping the most rapid current rushing through the lock at the time.

With this great advance in such improvements, our great agricultural interests will receive one of the greatest impulses to an onward increased operation in every part of the interior of our country, and the government may possess itself of means of traversing our country with any sized fleets of shipping they will use for defense on the ocean. In proof of what has been stated we will give the results of the passing one lock of a definite size; say a lock two hundred feet long and thirty-four feet wide in the chamber, with ten feet lift, will contain sixty-eight thousand cubic feet of water, and that quantity can be let in or discharged in less than two minutes of time, and thus any larger size of lock will operate in the same ratio of time as it varies in size. One other immense advantage is gained in this improvement by being able to construct these locks of the most durable materials, such as cast-iron gates, &c.

From the above circular it will be seen that the invention consists, in the first place, in a mode or system of operating, economizing, and facil-

itating the transportation of the commerce of the country on rivers and canals, thereby revolutionizing nearly all of the present modes, and in the second instance by presenting for consideration a design by means of which the system can be adopted in practice. The device or plan of the invention has already been described, and its several advantages and disadvantages commented upon in great detail; it is now intended to examine the proposed system of navigating canals, which for convenience will be designated the "pool system," to ascertain whether it is a desirable one; and if so, what practicable benefit will arise from its application. This subject is one of vast importance in a commercial point of view, and the proposed change is of such a radical nature and involves so many contingencies, each demanding its own specific weight, that but little more can be here attempted than to call attention to the more important elements of the problem, leaving its solution to those who may possess sufficient data for that purpose. Referring to the requirements of the "pool system," it may be assumed that the width of the whole canal or water-way must either be wide enough to allow two fleets, of description mentioned in the circular, to pass, or the form of either or both must be changed for that purpose. In other words, the fleet must habitually be towed in a single line of boats, and be doubled up on entering the lock, or the whole canal must be made wide enough for four boats abreast, two in each fleet, to move past each other without interruption. The present widths of some of the more important canals are as follows:

Canal.	Width at water-line.	Width of lock.
English, (generally)	36 to 40 feet	15 feet.
Caledonia, (Scotland)	110 feet	40 feet.
French, (generally)	52 feet	17 feet.
Erie, N. Y., (before enlargement)	40 feet	15 feet.
Erie, N. Y., (after enlargement)	70 feet	18.8 feet.
Chesapeake and Ohio	60 feet	15 feet.
James River	50 feet	15 feet.
Welland, (originally Canada)	56 feet	22 feet.
Long Sault and Cornwall, (St. Lawrence River)	132 feet	43 feet.

According to the "pool system" the above dimensions would have to be increased, and the figures would stand as follows:

Canal.	Width at water-line.	Width of lock.
English	60 to 64 feet	30 feet.
Caledonia	160 feet	80 feet.
French	86 feet	34 feet,
Erie, (before enlargement)	68 feet	30 feet.
Erie, (after enlargement)	112 feet	37.6 feet.
Chesapeake and Ohio	102 feet	30 feet.
James River	80 feet	30 feet.
Welland	80 feet	44 feet.
Long Sault and Cornwall	218 feet	86 feet.

Whether the advantages gained by the "pool system" would compensate for the enlargement of any canal as above indicated, would depend upon the amount of traffic and other considerations which it is unnecessary to mention. Should it, however, be found more expedient to tow the boats in a single line, considerable delay must ensue at each lock; a question then arises whether the time thus lost would not be equal to, if not greater than, that which would result from the ordinary course of procedure. It might appear that the fleet could be towed habitually in

two lines, and undouble on passing other fleets; but since the number of boats passed is generally much greater than the number of locks on any canal, this would evidently be less advantageous than the other plan. Where these locks are intended to pass boats from one pond to another, in the case of slack-water navigation in rivers, these considerations would of course not apply, as a sufficient width of water-way is generally to be found in such cases. In the second place it must be taken into consideration that a sufficient quantity of water will have to be supplied to canals with a summit level to make up for the quantity required to fill it and its dependent levels in consequence of the additional "expenditure" due to the greater size of the lock-chambers and pools, and the greater displacement of water by the fleet. This would increase the cost of feeders and reservoirs, which is a very considerable item in the estimate for constructing many of the present canals, and in some cases it might preclude the use of this system altogether. It would also follow that the currents, which always exist in canals from the summit level to the waste-weirs in the lower levels, would be increased in the same ratio. These currents, besides wearing the banks of the canal, retard boats moving against them, more than they accelerate those pursuing the same direction, and consequently cause a dead loss of power. In the third place, as stated in the circular, the use of steam-power must entirely supersede that of horses in propelling boats through canals; unless the requisite number of them arrive at the lock simultaneously, those coming first must be detained until others arrive, otherwise a greater quantity of water must be expended and time consumed in passing one or two isolated boats than would be required for a whole fleet; the prisms of lift and draught, or contents of the lock, would be the same, while the displacement of the boats would be less in the same proportion as their number is less than that of the fleet. While it is probable that steam will eventually replace that of horse-power, still from the present nature of canal traffic the number of boats in a fleet will be very variable and many isolated ones will be continually passing. This will, however, be remedied by the constantly increasing amount of transportation by this mode, as soon as any decided improvement is effected for facilitating commercial operations. There are many and great reasons why extensive improvements of the kind should be inaugurated in the United States; an uninterrupted system of canal and river transportation extending over the entire country has become an absolute necessity both for commercial and military purposes.

When the several causes of disqualification, or disadvantages, do not exist, or where they are small in comparison with the benefits to be gained, the "pool system" may be successfully employed, and there is no doubt the advantages will be fully equal to those claimed by Mr. Bishop in the circular already quoted. The suggestions submitted and the alterations proposed after careful examination and study of the plan of a new lock gate as presented by him for the consideration of the board ordered to investigate it, far from lessening the merits of the invention, are calculated to render it more deserving of attention in the minds of practical engineers by at once removing the objections which might arise against some of the constructive details of its mechanism or the more advanced theories of its usefulness; these, however, have nothing to do with the application of the inventor of the grand principle applied in arranging the gates in the manner presented in his plan.

ADAPTATION OF THE PLAN TO THE WASHINGTON CANAL.

The above conclusions, and the fact that the Washington canal is, at least nominally, under consideration by another board of engineers, by whom a preliminary report has been submitted, would seem to leave but little to be said in regard to another division of the subject of this report, that of "the adaptation of Mr. Bishop's invention to aiding in the construction of a ship canal through the city of Washigton." As it may be considered, however, by others as an auxiliary to a general plan for improving the canal through the city, it would not be irrelevant at this time to record some general observations on this subject. The history, objects, and condition of the Washington canal have contributed a very considerable portion to the literature of the city for many years, and the various reports on the work in question, and projects for its improvement, would form a volume of matter of such magnitude as to render a revision of the whole subject too elaborate to be attempted here, especially as one does not appear to be necessary in this connection. The canal has been used since its construction for two purposes; the one for navigation, and the other as a main, open sewer; it has been the receptacle of the sewerage of the larger portion of the city, as well as of the surface drainage and the debris washed down through the bed of Tiber Creek. In consequence, it has been gradually filling up with a mass of most deleterious matter, and to such an extent as to render it not only entirely useless for the greater part of its length for the passage of boats, but to cause it to become a public nuisance. Attempts have been made during the last two or three years to partially abate the latter by removing a portion of the deposit by dredging, and by flooding the remainder by means of tide gates; but after repeated efforts these means proved to be, as they were intended, only temporary expedients, and cannot be considered as having produced any very beneficial results. The various projects for the permanent improvement of the canal may be divided into three classes: the one proposes to continue the use of it both for its legitimate purpose and as a sewer combined; in other words, to let it remain in its present status; the other to employ it entirely for the transportation of boats and to build a covered sewer parallel to it; while the third plan suggested is to fill it up excepting so much as may be necessary for a proper sewer, and discontiuuing its use as a canal altogether.

Mr. Bishop's project belongs to the first of these classes. In general terms he proposes to extend the canal up the river to Georgetown; to cut off the present sharp bends at different points; to place locks at its junction with the Potomac and Eastern Branch, and to replace the present permanent bridges across it by turning or draw bridges, in order to allow vessels of all descriptions to pass. In addition, as part of this plan, the Georgetown or Virginia channel of the Potomac is to be closed, and thus divert the tide of commerce from its present channel, and direct it through the new one. He also contemplates to clear the canal and keep it free from objectionable matter by opening the gates and completely flooding it at certain stages of water in the river. Without entering into the details of this project, it may be stated that the requirements of a navigable canal and a suitable sewer are incompatible, and that in general whatever tends to improve the one necessarily injures the other. For example, a good sewer should have a declivity of at least one foot in a thousand, while the canal should be as nearly level as possible; the sewer should be no larger than is requisite to carry off all the semi-fluid mass or water that can find its way into it from its lateral

branches or from surface drainage, while the larger the section of the canal within reasonable limits the better; the sewer requires to be covered while the canal remains open. The board cannot, therefore, recommend any project in which it is contemplated to use the same channel for the two purposes, however feasible the details of such an undertaking may be. It is a well known fact that along the wharves of all large cities there is a constant deposit from the contents of the sewers, which necessitates either almost continuous dredging, or the extension of the piers beyond its influence.

There is no doubt that any canal, receiving the constantly accumulating matter from a great portion of the sewerage of a large city, must be filled sooner or later unless there is a very strong and constant current through its entire length. In this case there is no possibility of producing such a current without extending the canal up to some point at or near the Chain or Little Falls bridge, some three miles above Georgetown, even then the velocity of water at the sides and bottom of a long narrow channel is so much retarded by friction, that while there might be a sufficient strength to the current at the middle of the canal, a deposit would probably form on the sides and bottom. This would take place even in a constant current when the floating material is kept in motion and scarcely allowed to settle and become compact, how much more then would it obtain when locks were introduced, and the force of the water allowed to exert its influence only at intervals. That part of Mr. Bishop's project, which contemplates the substitution of turning or draw bridges for the present permanent ones over the canal cannot reasonably be entertained. The canal now separates the main portion of the city from that section fronting on the Potomac, along which at the present time the larger number of wharves have been constructed for commercial purposes. To interfere or interrupt the constant travel and hauling of heavy freight on the streets leading from them would prove a very great injury to trade and the improvements now projected in their vicinity. Even should benefit arise to one part of the city by enlarging the dimensions of the canal so as to enable sea-going vessels to enter, it would scarcely compensate for the expense of the undertaking, and the damage that would be sustained by another and a very rapidly improving portion. Should the money necessary to execute such a work be applied to dredging and opening the old Washington channel along the whole water front of the city, it would prove a more profitable and beneficial expenditure. A long and continous line of wharves, extending from the Arsenal Point to the foot of the Little Falls, could then be built. The closing, as intimated in the method of improvement referred to, of an old and well established channel like the Georgetown or Virginia one, for the purpose of opening another and a more circuitous one through the heart of a large city, would scarcely meet with very favorable consideration in any point of view; the only practicable and intelligent plan of operations is to accomplish by mechanical means what nature originally designed should be the case, the reopening of the old channels as they existed before any encroachments were made upon them, or any obstructions allowed to be interposed to their detriment. In closing this division of the report, the board cannot look upon the facts just stated as being in any way discouraging to those interested in the improvement of the Washington Canal. If it cannot be made to serve two purposes, there is no reason why it should not be made useful in accomplishing one good result, one object well accomplished will certainly prove more profitable than two imperfectly executed. It is susceptible of a mathematical demonstration that should either the second or third

of the general plans referred to for the improvement of the Washington Canal be adopted, in other words, should the canal be properly cleaned out, narrowed, straightened as much as possible, and a good sewer built parallel with it, the arch over the lower portion of Tiber Creek being also extended as high up as the boundary of the city limits, or should the canal be discontinued as such, and a portion of its width converted into a proper sewer, and in connection with this, should the main channel of the Potomac be diverted towards and along the Washington shore, the value of the land reclaimed, and the rise in the price of property effected by the change, would more than pay the cost of the whole undertaking, to say nothing of the vast improvement that would accrue to the city by benefiting its sanitary condition.

Before closing it may not be considered irrelevant to add some general information in regard to canals and navigable rivers, and the improvements in connection with them. The tables D, E, and F, which are appended, contain lists of the canals and river improvements already existing, or which are contemplated in the United States.

The authorities from which the data are obtained are as follows:

1. Report upon the Physics and Hydraulics of the Mississippi River, by Captain A. A. Humphreys and Lieutenant H. R. Abbott, topographical engineers, 1861.
2. Report of the State Engineer and Surveyor of the State of New York for 1863.
3. Report of the State Engineer and Surveyor of the State of New York for 1866.
4. Report of the Superintendent of the United States Census of 1860.
5. Archives of the Headquarters Corps of Engineers, United States Army.
6. Proceedings of the National Ship Canal Convention, held at Chicago, June 2 and 3 1863.
7. History of the Ohio Canals, prepared from public documents of 1862.
8. Bishop Davenport's Gazetteer and Geographical Dictionary.

The statistics herewith submitted concerning some of the existing canals are collected principally from the above-mentioned sources, and the data thus furnished tend to demonstrate not only the importance of providing additional facilities for the transportation of freight, but also the very urgent need for them. A great many facts were presented during the session of the National Ship Canal Convention, which was called together for the purpose of discussing the subject of "the enlargement of the canals between the valley of the Mississippi and the Atlantic," being regarded "as of great national, commercial, and military importance, and as tending to promote the development, prosperity, and unity of our whole country."

The substance of the proceedings of this convention, consisting of about two thousand five hundred members, representing the mercantile interest of Maine, New Hampshire, Vermont, Connecticut, Massachusetts, Rhode Island, New York, New Jersey, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, Iowa, Minnesota, Missouri, Kentucky, Kansas, Dacotah Territory, and the District of Columbia, is summed up in the following resolutions, and which were unanimously adopted.

The representatives of the States, assembled in national convention in Chicago, desirous of cementing a closer union, of perpetuating our nationality forever, of providing for the common defense, and promoting the general welfare of our whole country, adopt the following resolutions:

Resolved, That we regard the construction and enlargement of canals between the Mississippi River and the Atlantic, with canals duly connecting the lakes, as of great

national, military, and commercial importance; we believe such construction and enlargement, with dimensions sufficient to pass gunboats from the Mississippi to Lake Michigan, and from the Atlantic to and from the great lakes, will furnish the cheapest and most efficient means of protecting the northern frontier, and at the same time will promote the rapid development and permanent union of our whole country.

Resolved, That these works are demanded alike by military prudence, political wisdom, and the necessities of commerce; such works will be not only national but continental, and their early accomplishment is required by every principle of sound political economy.

Resolved, That such national highways between the Mississippi and the lakes, as far as practicable, should be free, without tolls and restrictions; and we should deprecate the placing this great national thoroughfare in the hands of any private corporation or State. The work should be accomplished by national credit, and as soon as the cost is reimbursed to the national treasury, should be as free as the lakes to the commerce of the world.

An executive committee of one from each State was appointed, which prepared and submitted a memorial to the President and the Congress of the United States, presenting the views of the convention, and urging the passage of the necessary laws to carry them into full effect. The memorial urges the necessity of large ship canals between the East and the West, both for military and commercial purposes. In reference to the importance of the first it contains a very interesting description of the exposed condition of our northern frontier compared with the complete and well-established defenses of Canada, consisting of fortifications and canals; those connecting the Atlantic with Lake Ontario have locks forty-five feet in width, two hundred feet in length, and eight feet in depth. By these water communications, and the Welland Canal, the latter connecting Lakes Erie and Ontario, with locks twenty-six feet wide, one hundred and fifty feet long, and eleven feet deep, Great Britain can "send a whole fleet of gunboats, with the most powerful of screw corvettes, to carry the protection of the British flag from Montreal to Detroit."

To resist such measures, the United States are, as yet, entirely powerless. The chairman of the Committee on Military Affairs of the House of Representatives, in 1863, employed the following forcible language:

A small fleet of light draught, heavily armed iron-clad gunboats could in a short month pass up the St. Lawrence into the lakes, and shell every city from Ogdensburg to Chicago. It could at one blow sweep our commerce from the entire chain of waters. Such a fleet could have it in its power to inflict a loss to be reckoned only by hundreds of millions of dollars, so vast is the wealth thus exposed to the depredation of a maritime enemy.

The memorial proposes the enlargement of the connection of Lake Michigan with the Mississippi River; the construction of a ship canal around the Niagara Falls; and the enlargement of the Erie and Oswego canals.

In reference to the commercial importance of the improvements enumerated, the signers of the memorial make use of the brief but expressive sentence, "We have outgrown our canals." They say still further, "the necessity of the enlargement of the canals is manifest by the enormous profits of the great railways and the extravagant rates of transportation, showing that the quantity to be carried forward is so vast that the carriers command their own terms."

The annexed graphical sketch (G) is intended to represent the progress of the trade on the Erie Canal from the year 1835 to 1862, both included, as gathered from the annual report of the State engineer and surveyor of New York for 1863. No statistics of the seasons succeeding 1862 could be found. The broken line in the sketch shows the amount of freight arriving at tide-water, and the full line, the total amount including both that leaving and arriving at tide-water. The broken and

dotted line representing the amount of freight going east, and the dotted line the total amount going both ways, exhibit apparently the average increase from year to year between 1835 and 1862, and prove said increase to become greater and greater every successive season. The total lockage at Junction and Alexander's lock for 1862 was 42,866, making the daily passage 204. The cost of transportation (tolls and freight) was $16 per ton in 1835, from Albany to Buffalo, and $6 29 per ton from Buffalo to Albany; it was reduced in 1862 to $12 50 from Albany to Buffalo, and $4 22 from Buffalo to Albany. This reduction was in a great measure attained by the gradual enlargement of the canal, and in the increased size of the boats used. The report of the committee on statistics, appointed by the convention at Chicago, contains a statement of the Hon. N. S. Benton, auditor of the canal department of New York, which furnishes the following increase in the size of the boats employed: the average size of boats in 1842 was forty-two tons; in 1847, sixty-five; in 1852, eighty; in 1857, one hundred; and in 1862, one hundred and sixty-seven tons. The State engineer and surveyor says in his annual report for 1863, in reference to the reduction of the rates of transportation, that "to accomplish this important result the State expended for the enlargement of the Erie Canal, including land damages and interest on loans, $43,639,268 34.

But to make the enlargement complete and efficient, it should be followed by a proportionate increase in the dimensions of the locks in order to give them sufficient capacity. The authority above quoted says, in his paper of 1866, in reference to the enlargement of the State canals so as to admit of the passage of gunboats, a subject already debated in the New York legislature, that "the plan of the enlargement of the capacity of the locks to tide-water is the practical solution of the difficulty, and will secure us for the present in the continued control of this great traffic by furnishing to it a quicker, safer, and cheaper route than can be found elsewhere." "But so rapidly is the great West increasing in population and all the elements of national wealth and prosperity, even this relief can only be adequate for a limited number of years." "One tier of enlarged locks, with a capacity of chamber two hundred and twenty feet in length between the quoins, and a width of twenty-five feet at the top-water line of the lower level, will admit the passage of boats with six feet draught of water, equal to a tonnage displacement of six hundred and eighty-four tons or a cargo of five hundred tons, and, with an equal distribution of boats, a capacity of five million tons in each direction, per season." "The cost of transportation, as compared with boats of the present tonnage, will be reduced from 2.16 to 1.44 mills, per ton, per mile, based upon the movement of horse-power." "The experiments thus far made with use of steam as a motor have been unsuccessful. This result is attributable to the want of capacity in the locks. The room occupied by the power necessary for rapid transit is too great, as compared with the space remaining for storage of cargo, to make its use economical. This difficulty will be greatly lessened, if not entirely removed, by the use of large boats." In a statement which was submitted by the Corn Exchange of New York, and the Board of Trade of Buffalo, to the joint committee on canals of the New York legislature in 1863, the inefficient capacity of the locks on the State canals is set forth as follows:

"The fact was shown that, during considerable portions of the last three years, the Erie Canal had been taxed to its utmost capacity, not from deficiency in its main trunk, but from the impossibility of

passing more boats through its locks; that while the channel of the canals was sufficient to be navigated by boats of six hundred tons burden, the present locks could pass boats of about two hundred tons only; that, while the channel of the canals in question was seventy by seven, the locks were but ninety-seven by eighteen; that multiplying boats would not increase the transportation of tonnage for the reason the limit of lockage had already been reached; that while the channels of the Erie and Oswego canals (with resources at command) were probably sufficient for the transportation of twenty-five million tons annually, the capacity of the present locks had been reached the present season at two million nine hundred thousand tons. The statement shows by tables furnished by the auditor of the canal department that the lockages for the three most active months of 1860 (September, October, and November) were fifteen thousand four hundred and twenty at Frankfort, the locks being double. An addition of six hundred and nineteen new boats in the same three months of 1861, only caused an increase of one hundred and sixty-five instead of three thousand seven hundred and fourteen, allowing each new boat three trips either way. Another addition of eight hundred and fifty new boats in 1862, which during the same three months with adequate locks ought to have caused an increase in lockage of eight thousand nine hundred and ninety-four over 1860, was followed by an increase of lockage of only one thousand six hundred and sixty-three. The last increase was obtained by the utmost exertions in every respect, and by the application of stationary power." The statement then adds that "the inadequacy of the locks to the present channels of the canals was further illustrated by the many miles of boats constantly accumulated at Rochester, waiting their time at the Brighton lock, so called, and at Syracuse, at the first lock east of the junction of the Oswego Canal; showing that while these boats had passed readily along the levels, they suffered detention only at the locks; thus, while ten to twelve days should be ample time to run a loaded boat from Buffalo to New York, eighteen to twenty-two are now required, consequently a loss of time of nearly thirty-three per cent."

The foregoing data show conclusively that the delay and consequent loss in the shipment of goods through the present canals, so seriously embarrassing to commerce, does not arise from their general construction, but is principally owing to the size of their locks; the latter are too small in proportion to the profile of the canals. Being incapable of furnishing transit to more than a limited number of the many boats that traverse with ease and rapidity the levels connecting them, their progress is greatly retarded and commerce impeded, the cost of transportation, in consequence, ruling at inconveniently high rates. Any alteration in the devising of locks that lessens the cost of construction and expedites the passage of boats, as by some improved mechanical apparatus for filling and emptying the chamber, will be welcomed as an advanced step toward the accomplishment of the scheme under consideration. The preceding information in regard to existing canals, as well as the data for compiling the annexed tables, has been principally compiled, under the direction of the board of engineers, by Mr. Bishop, the inventor of the plan of improved lock submitted to it for examination, assisted by Mr. John de la Camp, civil engineer; the latter also, as already stated, prepared the drawings of the plan from the models of the lock presented for the inspection and report of the board.

N. MICHLER,
Major of Engineers, Bvt. Brig. Gen. U. S. A.

While concurring generally in the views submitted above, it seems proper to add that it is impossible to decide, from an examination of a small model, as to the actual commercial value of an arrangement like Mr. Bishop's. It is ingenious, but I do not believe it will effect the revolution in the canal navigation that he seems to anticipate. Its real value can only be ascertained by using it on some existing or projected canal. Its advantages do not appear to me so manifest or so great as to justify a recommendation that Congress be asked to appropriate the money to make a practical trial of it. If any canal company be found willing to give the invention a test, by building such a lock and proving its value by actual use, none will be more interested than myself in the experiment or more gratified to learn that Mr. Bishop's hopes and expectations are fully realized.

I am unable to perceive the necessity or propriety of having a ship canal through the city of Washington, whether it be built at the expense of the general government or of the corporation of Washington. Being of this opinion, it is scarcely necessary to add, that the locality does not seem to be a favorable one for the application of Mr. Bishop's canal lock.

WM. P. CRAIGHILL,
Major of Engineers, Bvt. Lieut. Col. U. S. A.

I concur.

W. R. KING,
Captain of Engineers, Bvt. Maj. U. S. A.

A.—*Detailed estimates of a canal lock, eight feet lift, old plan.*

Grubbing and clearing	$200 00
Bailing and draining	1,500 00
Excavation of earth-work, 20,600 cubic yards, at 30 cents	6,180 00
Embankment, 3,000 cubic yards, at 30 cents	900 00
Lining, 3,200 cubic yards, at 50 cents	1,600 00
Puddling earth, 360 cubic yards, at 30 cents	108 00
Slope wall and pavement, 660 cubic yards, at $1 75	1,155 00
Loose stone, 170 cubic yards, at $1 25	212 50
Vertical wall, in cement, 120 cubic yards, at $5	600 00
Vertical wall, dry, 480 cubic yards, at $3 50	1,680 00
Masonry in lock walls, 3,006 cubic yards, at $12 50	37,575 00
Concrete masonry, 350 cubic yards, at $4	1,400 00
White oak timber, &c., 42,600 feet, board measure, at 70 cents	2,982 00
White pine timber, &c., 16,800 feet, board measure, at 50 cents	840 00
Hemlock timber, &c., 220,000 feet, board measure, at 25 cents	5,500 00
Bearing piles, delivered, 19,000 lineal feet, at 20 cents	3,800 00
Bearing piles, driven, 16,000 lineal feet, at 15 cents	2,400 00
Wrought iron, 16,100 pounds, at 15 cents	2,415 00
Cast iron, 11,850 pounds, at 10 cents	1,185 00
Spikes and nails, 5,000 pounds, at 10 cents	500 00
Sulphur and sand cement, per lock	100 00
Painting lock gates, per lock	30 00
Snubbing posts, 100 lineal feet	60 00
	72,722 50

B.—*Detailed estimates of a canal lock, eight feet lift, new plan.*

Grubbing and clearing	$200 00
Bailing and draining	1,500 00
Excavation of earth, 15,044 cubic yards, at 30 cents	4,513 20
Embankment, 3,000 cubic yards, at 30 cents	900 00
Puddling earth in foundation, 600 cubic yards, at 20 cents	120 00
Masonry in lock-walls, foundation, and section, 280 cubic yards, at $12 50	3,500 00
Masonry in four piers in gate chamber, 156 cubic yards, at $7	1,092 00
Masonry in the breast of the lock, 102 cubic yards, at $5	510 00
Pavement at the head of the lock, 87 cubic yards, at $2 25	195 75
Foundation timber, 12,000 feet, board measure, at 25 cents	300 00
Floor plank, three inches thick, 3,550 feet, board measure, at 50 cents	1,775 00
Gate timber plank, &c., pine, 4,639 feet, board measure, at 50 cents	231 95
Foundation timber for second section, 72,000 feet, board measure, at 25 cents	1,800 00
Floor plank, of three inches thick, for second section, 25,200 feet, board measure, at 50 cents	1,350 00
Floor plank, of two inches thick, for second section, 10,920 feet, board measure, at 50 cents	546 00
Masonry in lock walls, second section, 1,568 cubic yards, at $12 50	19,600 00
Masonry in third section, 368 cubic yards, at $12 50	4,500 00
Masonry in four piers in gate section, 212 cubic yards, at $7	1,484 00
Masonry in lower chamber under side walls, 55 cubic yards, at $7	385 00
Foundation timber, 12,890 feet, board measure, at 25 cents	322 25
Timber and plank for lower gate, 4,821 feet, board measure, at 50 cents	241 00
Bearing piles, in lineal feet, 4,500 lineal feet, at 20 cents	900 00
Wrought iron for the first section, 4,141 pounds, at 15 cents	621 15
Wrought iron for the first section, 1,711 pounds, at 20 cents	342 20
Cast iron for the first section, 21,401 pounds, at 10 cents	2,140 10
Wrought iron for the third or lower section, 3,565 pounds, at 20 cents	713 00
Wrought iron for the third or lower section, 3,491 pounds, at 15 cents	524 55
Cast iron for the third or lower section, 22,434 pounds, at 10 cents	2,243 40
Screw-bolts and spikes for the whole lock, 3,000 pounds, at 15 cents	450 00
Material for cement	100 00
Painting gates	50 00
Snubbing posts	60 00
	53,210 55

C.

Grubbing and clearing	$200 00
Bailing and draining	1,500 00

Excavation of earth, 15,786 cubic yards, at 30 cents......	$4,735 80
Embankment, 1,500 cubic yards, at 30 cents.............	450 00
Masonry in the lock walls of first section, 280 cubic yards, at $12 50..	3,500 00
Masonry in four piers in gate chamber, 156 cubic yards, at $7	1,092 00
Rubble masonry in breast of the lock, 102 cubic yards, at $5	510 00
Pavement at the head of the lock, 87 cubic yards, at $2 50	217 50
Foundation timber, 12,000 feet, board measure, at 25 cents	300 00
Floor plank, of three inches thick, 3,550 feet, board measure, at 50 cents....................................	177 50
Floor plank, of two inches thick, 2,000 feet, board measure, at 50 cents..	100 00
Timber and plank for the gate, 4,639 feet, board measure, at 50 cents..	231 95
Pavements of the sides and bottom, middle section, to be grouted with cement, 1,833 square yards, at $4.........	7,332 00
Masonry in lock walls of third section, 400 cubic yards, at $12 50	5,000 00
Masonry in four piers of third section chamber, 212 cubic yards, at $7..	1,484 00
Masonry return of walls at lower end, 55 cubic yards, at $12 50	685 50
Foundation timber in third section, 12,890 feet, board measure, at 25 cents....................................	322 25
Floor plank, of three inches thick, third section, 5,400 feet, board measure, at 50 cents..........................	270 00
Floor plank, of two inches thick, third section, 3,600 feet, board measure, at 50 cents..........................	180 00
Timber and plank for the gate, third section, pine, 4,821 feet, board measure, at 50 cents.....................	241 00
Bearing piles, (lineal feet,) at 20 cents..................	713 00
Wrought iron for first section, 4,141 pounds, at 15 cents..	621 15
Wrought iron for first section, 1,711 pounds, at 20 cents..	342 20
Cast iron for first section, 21,401 pounds, at 10 cents......	2,140 00
Wrought iron for third section, 3,565 pounds, at 20 cents..	713 00
Wrought iron for third section, 3,491 pounds, at 15 cents..	524 55
Cast iron, 22,434 pounds, at 10 cents.....................	2,243 40
Screw bolts and spikes, 2,000 pounds, at 15 cents.........	300 00
Puddling earth in foundation, 300 cubic yards, at 20 cents	60 00
Materials for cement.....................................	200 00
Painting gates..	50 00
Snubbing posts..	60 00
	36,496 80

D.—*Statement of canal and river improvements existing in the United States.*

Name and State.	Length of canal.	Slack-water navigable.	Total lift.	Number of locks.	Extreme points.
	Miles.	*Miles.*	*Feet.*		
Cumberland to Oxford, Me	20½	......	168	26	
Songo River improvement, Me	....	30	8	1	
Canals around Merrimac River Falls, N. H.	7	......	156	30	
Canals around Connecticut River Falls, Vt.	12	......	205	25	
Canals on branches of Connecticut River, Vt.	29	......	not ascertained.		
Middlesex Canal, Mass	29	......	130	17	Boston to Chelmsford.
Enfield Canal, Conn	5½	......	20	2	Around Enfield Falls on Connecticut River.
Erie Canal, N. Y	363	......	675	71	Albany to Buffalo.
Genesee Valley Canal, N. Y	125	......	1,064	114	Rochester to Olean.
Cayuga and Seneca Canal, N. Y	25	......	77	11	Montezuma to Geneva.
Crooked Lake Canal, N. Y	8	......	278	27	Dresden to Penn Yan.
Chemung Canal, N. Y	39	......	490	49	Head of Seneca Lake to Elmira.
Chenango Canal, N. Y	97	......	1,015	114	Utica to Binghamton.
Oswego Canal, N. Y	38	......	155	18	Syracuse to Oswego.
Black River Canal, N. Y	50	......	1,082	109	Rome to High Falls.
Black River improvement, N. Y	42	......	not ascertained.		High Falls to Carthage.
Champlain Canal, N. Y	74	......	178	20	Grand Junction to Whitehall Lake.
Oneida Lake Canal, N. Y	7	......	60	7	Higginsville to Oneida Lake.
Oneida River improvement, N. Y	20	......	not ascertained.		Oneida Lake to Oneida River.
Delaware and Raritan Canal, N. J	43	......	150	15	Bordentown to New Brunswick.
Delaware Feeder, N. J	22½	......	4	1	
Morris Canal, N. J	101	......	1,674	212	Jersey City to Phillipsburg.
Delaware and Hudson Canal, Pa	108	......	950	105	Eddysville to Honesdale.
Lehigh Navigation, Pa	39	45	1,297	78	Stoddartville to Easton.
Schuylkill Navigation, Pa	....	108½	616	70	Philadelphia to Port Carbon.
Delaware Division, Pa	60	......	167	24	Easton to Bristol.
North Branch Canal, Pa	105	......	258	27	Wilkesbarre to New York State line.
Wyoming Canal, Pa	64	......	69	8	Wilkesbarre to Northumberland.
West Branch and Susquehanna Canal, Pa.	117	......	225	31	Farrandsville to Duncan's Island.
Union Canal, Pa	77	......	503	84	Reading to Middletown.
Pine Grove Branch Canal, Pa	22	......	not ascertained.		Union Canal to Pine Grove.
Susquehanna and Tide-water Canal, Pa.	45	......	233	29	Wrightsville to Havre de Grace.
Pennsylvania Canal, Pa	156	......	671	76	Columbia to Hollidaysburg.
Western Division Canal, Pa	76	......	469	45	Johnstown to Pittsburg.
Monongahela navigation, Pa	....	90	75	4	Pittsburg to Genesee.
Youghiogheny navigation, Pa	....	18	27	2	McKeesport to West Newton.
Erie Canal, Pa	136	......	930	133	Bridgewater to Erie City.
French Creek Feeder, Pa	27	......	128	16	Bemus Dam to main canal.
Wisconiso Canal, Pa	12	......	35	6	Wisconiso Creek to Duncan's Island.
Conestoga Canal, Pa	....	18	50	6	Lancaster and Susquehanna.
Little Schuylkill Canal, Pa	25	......	50	6	Mouth of Little Schuylkill to coal mines.
Chesapeake and Delaware Canal, Del.	13	......	32	3	Delaware City to Back Creek.
Chesapeake and Ohio Canal, Md	184½	......	606	74	Georgetown to Cumberland.
Ohio and Erie Canal, Ohio	307	......	1,085	152	Portsmouth to Cleveland.
Ohio and Erie Canal, Columbus branch, Ohio.	14	......	11	2	Main canal to Columbus.
Ohio and Erie Canal, Lancaster branch, Ohio.	9	......	11	2	Main canal to Lancaster.
Ohio and Erie Canal, Zanesville branch, Ohio.	16½	......	27	3	Main canal to Zanesville.
Ohio and Erie Canal, Athens branch, Ohio. (Hocking Canal.)	56	......	208	26	Main canal to Athens.
Ohio and Erie Canal, Granville branch, Ohio.	5	......	16	2	Main canal to Granville.
Ohio and Erie Canal, Walhonding branch, Ohio.	23	......	90	11	Main canal to Coshocton.
Miami and Erie Canal, Ohio	265	......	887	100	Cincinnati to Defiance.
Miami and Erie Canal, Lebanon branch, Ohio.	20	......	not ascertained.		Main canal to Lebanon.
Sandy and Beaver Canal, Ohio	86	......	350	44	Bolivar to Liverpool.
Sandy and Beaver Canal, Canton branch, Ohio.	14	......	not ascertained.		Main canal to Canton.
Mahoning Canal, Ohio	87	......	343	43	Acron to Pennsylvania State line.
Muskingum River improvement, Ohio.	....	91	101	12	Dresden to Marietta.
Wabash and Erie Canal, Ind	469	......	500	63	Evansville to Toledo.
Whitewater Canal, Ind	94	......	500	63	Cincinnati to Cambridge City.
Chicago and Illinois Canal, Ill	320	......	170	21	Chicago to La Salle, (partly finished.)

D.—*Statement of canal and river improvements, &c.*—Continued.

Name and State.	Length of canal.	Slack-water navigable.	Total lift.	Number of locks.	Extreme points.
	Miles.	*Miles.*	*Feet.*		
Sault Ste. Marie Canal, Mich	1	......	19	2	Lake Superior to Lake Michigan.
Fox and Wisconsin River improvement, Wis.	....	289	362	45	Green Bay to Lake Michigan.
Des Moines River improvement, Iowa.	....	175	224	28	Keokuk to Des Moines City.
Louisville and Portland Canal, Ky	2½	......	22	4	Louisville to Portland.
Kentucky River Navigation, Ky	....	257	216	17	Mouth of Kentucky River to branch of North Fork.
Licking River navigation, Ky	....	231	310	21	Mouth of Licking River to West Liberty.
Green River navigation, Ky	....	175	60	8	Mouth of Green River to Bowling Green.
Barren River navigation, Ky	....	100	not ascertained.		
Alexandria Canal, Va., (two divisions.)	7	......	60	7	Alexandria to Washington Aqueduct.
James River and Kanawha Canal, Va.	196	......	672	84	Richmond to Buchanan.
Appomattox River improvement, Va.	57	61½	386	46	Petersburg to Planterstown, (partly finished.)
Dismal Swamp Canal, Va	28¼	......	33	5	Deep Creek to Joyce's Creek.
Dismal Swamp Canal, Lake Drummond branch, Va.	5	......	not ascertained.		Lake Drummond to main canal.
Jericho Canal, Va	9	......	not ascertained.		Lake Drummond to Nansemond branch, main canal.
Albemarle and Chesapeake Canal, Va.	8¼	......	not ascertained.		S. W. branch of Elizabeth River to North Landing River.
Albemarle and Chesapeake Canal, N. C.	5½	......	not ascertained.		Canijock Bay to North River.
Weldon Canal, N. C	12	......	100	12	Roanoke River improvement.
Clubfoot and Harlow Canal, N. C.	1¼	......	not ascertained.		Clubfoot Creek to Warlow Creek.
Santee River improvement, S. C.	22	128	103	13	Connecting Charleston Harbor, (partly finished.)
Winyaw Canal, S. C	7¼	......	not ascertained.		Winyaw Bay to Kinlock Creek.
Catawba Canal, S. C	6¼	......	not ascertained.		Several short canals.
Wateree Canal, S. C	4	......	not ascertained.		Jones's Mills to Ellicott's.
Saluda Canal, S. C	6	......	36	4	Head of Saluda Shoals to Granby Ferry.
Drehis Canal, S. C	1½	......	120	15	Round Saluda River Falls.
Lorricks Canal, S. C	1	......	not ascertained.		Broad River above Columbia.
Lockhart's Canal, S. C	2¾	......	not ascertained.		Around Lockhart's Falls in Broad River.
Brunswick Canal, Ga	12	......	not ascertained.		Brunswick Harbor to Altamaha River.
Ogeechee Canal, Ga	16	......	not ascertained.		Savannah to Ogeechee River.
Muscle Shoals Canal, Ala	36	......	96	16	Around Muscle Shoals of Tennessee River.
Huntsville Canal, Ala	16	......	not ascertained.		Huntsville to Friance.
Orleans Bank Canal, La	4	......	not ascertained.		
Barataria navigation, La	22	63	not ascertained.		
Carondelet Canal, La	2	......	not ascertained.		New Orleans to Bayou St. John.
Lake Veret Canal, La	8	......	not ascertained.		Lafourche Bayou to Lake Veret.
Total	4,710¼	1,880	22,104	2,567	

E.—*Statement of canal and river improvements contemplated in the United States.*

Name and State.	Length of canal.	Slack-water navigable.	Total lift.	Number of locks.	Extreme points.
	Miles.	*Miles.*	*Feet.*		
Nulhegan and Clyde Canal, Vt	38	......	624	78	
Black River and Ives's Brook, Vt.	53	......	880	110	
Barton and Passunsick Canal, Vt	51	......	928	116	
Niagara Ship Canal, N. Y	15	......	319½	36	Fort Grey to Old Fort Slusher.
Extension of Chesapeake and Ohio Canal, Md.	156¼	......	2, 583	324	Cumberland and Pittsburg.
James River to Kanawha Canal, 3d and 4th division, Va.	81	......	1, 490	123	Buchanan to Greenbrier Bridge.
Extension to Ohio River, via Greenbrier and Kanawha River, Va.	....	208	1, 158	145	Greenbrier to Point Pleasant.
Little Kanawha improvement, Va	....	108	181	22	To Parkersburg.
Santee River improvement, S. C	....	128	not ascertained.		
Savannah and Altamaha Canal, Ga.	66	......	not ascertained.		
Tippacanoe and St. Joseph Canal, Ill.	120¼	......	336	42	
Milwaukee and Rock River Canal, Wis.	53	......	288	36	
Florida Canal, Fla	250	......	434	54	
Total	884	444	9, 221½	1, 086	

F.—*Names of some of the greatest navigable rivers in the United States.*

	Length in miles.
Missouri River to the Great Falls	3, 150
Missouri River above Great Falls to the Three Forks	150
Yellowstone River	800
Osage to Osceola	200
Kansas River	100
Big Sioux River	75
Upper Mississippi River to St. Paul	658
St. Anthony to Sauk Rapids	80
St. Anthony above Little Falls to Pokegina Falls	250
Minnesota to Paterson's Rapids	295
St. Croix to St. Croix Falls	60
Illinois to La Salle	220
Ohio to Pittsburg	975
Alleghany to Condersport	290
Wabash to Lafayette	335
Salt to Shepherdsville	30
Sandy to Louisa	25
Tennessee to Muscle Shoals	600
Cumberland to Burksville	370
Red River	1, 200
Washita River	500
Arkansas River	1, 500
White and Black Rivers	800
St. Francis River	400
Des Moines River	400
Platte River, (both forks,) North Fork to mouth of Sweet Water River, South Fork to Denver	1, 060
Black Warrior River	200
Rio Grande to mouth of Pecos River	550
Pecos River	450

The descent of many of these rivers was ascertained, but the information being too incomplete it was omitted.

APPENDIX X.

Annual report of the survey of the Northern and Northwestern Lakes for the year ending June 30, 1869; Brevet Brigadier General W. F. Raynolds, United States Army, lieutenant colonel of engineers, in charge.

OFFICE UNITED STATES LAKE SURVEY,
Detroit, Michigan, September 25, 1869.

GENERAL: I have the honor to submit this, my annual report of the operations on the survey of the Northern and Northwestern Lakes, for the year ending June 30, 1869.

During the season of 1867 the field parties were engaged in the survey of Lake Superior. At the end of that season the portions of the lake unsurveyed were as follows:

1. The eastern side of the large bay south of Whitefish Point.
2. All that part of Isle Royale lying west of Rock Harbor on the south side and McCargoe's Cove on the north side.
3. All that portion of the west end of the lake west of a line drawn from Ontonagon to the mouth of Pigeon River, (excepting about twenty-five miles from the head of the lake which was surveyed in 1861.)

This last named field included the entire Apostle Island group, and, as the three districts combined were a larger field than could be covered by the force of the survey in a single season, it was determined to occupy only the most favorable months for work in Lake Superior, and then transfer the parties to the more genial climate and accessible locality of Lake St. Clair.

On the 1st of July, 1868, the date from which this report begins, the following parties were actively engaged in the field operations of the survey in Lake Superior, viz:

The steamer Ada, in charge of Captain F. U. Farquhar, Corps of Engineers, brevet lieutenant colonel United States Army, was engaged making a hydrographical survey of that portion of the south shore of Lake Superior between Eagle River and the Apostle Islands, and of the north shore of the same lake west of Isle Royale. Colonel Farquhar's instructions were, to follow the method heretofore adopted and make a thorough examination of the portions of the lake specified, from the limits of the work done by the shore parties, as far outward as it was practicable to have the position of the steamer accurately located by theodolites on shore.

He was also charged with the duty of selecting points on both sides of the lake for the primary triangulation, and directed to build the requisite stations for that purpose. This latter duty involved the careful examination of the heights near the shore, and, as they are all covered by a dense forest, the amount of labor required was far greater than would have been the case in a settled region.

The reconnoissance was carried so far as to leave but very little doubt that a system of triangles can be obtained that will cover the entire lake.

The off-shore hydrography of the northern coast of the lake was completed, and on the south coast the work was carried as far west as the mouth of the Montreal River.

First Lieutenant James F. Gregory, Corps of Engineers, with the party on board the steamer Search, was engaged in making a hydrographical survey around Isle Royale, including the channel between the north shore and that island, as well as the small islands and distant dangerous shoals lying to the northeast of the same.

Lieutenant Gregory was also charged with a general supervision of the topographical and hydrographical parties on Isle Royale, with instructions to keep them supplied with provisions, move their camps when required, carry their mails, &c.

The work done by this party was as follows:

Number of primary triangulation stations built	1
Number of sounding stations built	15
Number of sextant angles read	659
Number of theodolite pointings	1,914
Number of theodolite readings	3,762
Number of lines sounded with steamer	108
Number of miles sounded with steamer	1,358
Number of cast of lead from steamer	802
Number of square miles of off-shore hydrography	1,634
Number of observations for local time	5
Number of compass readings	86
Number of buoys put out for shore parties	9
Number of shore parties moved	6
Number of angles measured for triangulation	7
Number of miles run by steamer on general duty	3,653

First Lieutenant Benj. D. Greene and First Lieutenant John C. Mallery, Corps of Engineers, were in charge of topographical and hydrographical parties stationed on Isle Royale, the former on the southern and the latter on the northern side, with instructions to make a minute survey of their respective portions of the island, continuing their surveys until their work met and the survey of the island was completed. This island, though less than fifty miles in length, contains numerous indentations, bays, &c., and there are so many small detached islands adjacent to it that the survey was intricate and difficult and involved the survey of a shore line which, developed, is over three hundred miles in length. The water on all sides is of great depth and the bottom very irregular, the soundings frequently changing from many fathoms to a few feet between consecutive casts of the lead, which involved a very minute hydrographical examination in every part.

It is believed that the survey will prove of essential benefit to navigation, as dangers, before unknown, were discovered and numerous harbors and anchoring grounds, which have never been used, were shown to exist.

I therefore propose to have a chart made of the district on a scale that will show clearly all the features of the locality.

The work done by the above parties on Isle Royale was as follows:

LIEUTENANT GREENE'S PARTY.

Number of triangulation stations built	33
Number of sounding stations built	238
Number of topographical stations built	39
Number of buoys placed and located	130
Number of theodolite pointings	4,086
Number of theodolite readings	5,823
Number of lines sounded	967
Number of miles sounded	616
Number of casts of the lead	17,784
Number of square miles of hydrography	46
Number of miles shore-line run	84

Number of triangles measured	56
Number of compass bearings	40
Number of sextant angles	29

LIEUTENANT MALLERY'S PARTY.

Number of stations built	268
Number of sounding stations built	215
Number of buoys placed and located	179
Number of theodolite pointings	4,843
Number of theodolite readings	9,500
Number of lines sounded	1,227
Number of casts of the lead	12,928
Number of miles sounded	545
Number of square miles of hydrography	30
Number of miles stadia run	40
Number of miles shore-line run	80

Second Lieutenant Joseph E. Griffith, Corps of Engineers, aided by Assistant Henry Gillman, was in charge of topographical and hydrographical party on the south shore of Lake Superior charged with the duty of continuing the survey westward from near Ontonagon, Michigan, as far as possible. During the season's operations it was found necessary to transfer this party to the north side of the lake in order to secure the completion of the survey of that region.

The transfer was made after Lieutenant Griffith had been granted a leave of absence on account of his health, the party being left in charge of Assistant Gillman.

On the south shore the survey was carried as far as a point about four miles west of the mouth of Montreal River, (the dividing line between the States of Michigan and Wisconsin,) and on the north shore a survey of nineteen miles was made, which, with the surveys of Lieutenant Rogers and Assistant Mayers, completed the survey of the entire north shore of the lake from the mouth of Pigeon River, the boundary between the United States and the British possessions, and the head of the lake.

The total amount of work done by this party for the season was as follows:

Number of stations built	128
Number of buoys placed and located	115
Number of lines of soundings	679
Number of casts of the lead	20,525
Number of buoys made	39
Number of theodolite pointings	3,499
Number of theodolite readings	5,278
Number of miles stadia run	9½
Number of compass readings	54
Number of miles shore-line run and sketched	78
Number of miles topography run and sketched	14
Number of observations on Polaris	4

Second Lieutenant W. E. Rogers, Corps of Engineers, aided by Assistant Albert Molitor, was in charge of a topographical and hydrographical party on the north shore of Lake Superior working from the mouth of Pigeon River westward. Lieutenant Rogers's field covered that portion of Lake Superior where the national boundary leaves the lake and passes up Pigeon River toward the 49th parallel. He extended his survey

several miles into the British possessions north of the line, and then continued to the southwest along the lake shore through an exceedingly rough and inhospitable region, for the most part presenting a bold rocky shore almost destitute of inhabitants, until his work closed with that of the party of Lieutenant Griffith, which, as has been said, was transferred from the south shore to that locality.

The work done by this party was as follows:

Number of stations built	368
Number of buoys placed and located	170
Number of casts of the lead	13,491
Number of pointings of theodolites	3,687
Number of readings of theodolites	5,829
Number of readings of vertical angles	367
Number of readings of sextant angles	219
Number of base lines measured	4
Number of observations on Polaris	1
Number of miles measured by stadia	47
Number of miles shore-line run	89
Number of lines of soundings	690
Number of miles of soundings	624

Assistants J. R. Mayer and J. P. Mayer were in charge of a shore party on the north shore of Lake Superior, commencing at the most eastern point reached by the survey in 1861, and working to the eastward.

The whole survey of this portion of the lake, extending from near Duluth to opposite the western end of Isle Royale, was attended with privations and difficulties not met with in more favored localities; the almost entire want of communication, the absence of harbors, and to a great extent of even boat landings, the rough mountainous country covered by a dense forest, all combined to render the operations of the survey not only difficult, but dangerous, and I cannot but rejoice that the work has been finished successfully without an accident.

I do not think that as difficult and dangerous a coast line will be found on the entire chain of lakes.

The amount of work done by this party was as follows:

Number of secondary triangulation stations built	14
Number of sounding stations built	382
Number of buoys placed and located	208
Number of theodolite pointings	4,859
Number of theodolite readings	5,704
Number of miles soundings run	728
Number of lines sounded	1,306
Number of casts of the lead	18,277
Number of square miles of hydrography	67
Number of miles shore line run	116
Number of miles run with stadia for topography	58
Number of square miles of topography sketched	138
Number of miles lines of sight cut	3½
Number of meridian lines determined	4
Number of base lines measured	2

Assistant O. N. Chaffee, aided by Assistant A. F. Chaffee, was in charge of a party on board the steamer Surveyor, with instructions to commence work on the left bank of the St. Mary's River at the point above the falls where previous surveys ended, and work to the northward, passing the numerous bays and headlands above the head of that stream, and going

as far into the open lake as practicable, and at the same time to complete the triangulation of the large bay south and west of White-fish Point.

This party completed the survey in this point of the lake, having carried their work into British territory as far as the Mamaisue, a prominent headland about twenty miles northeast of White-fish Point.

The amount of work done was as follows:

Number of stations for triangulation built	21
Number of theodolite pointings	3,145
Number of theodolite readings	8,310
Number of miles shore-line run	14
Number of angles measured	59
Number of miles of shore-line run with stadia	91
Number of lines of soundings run with steamer	88
Number of miles of lines run with steamer	354
Number of casts of the lead from steamer	1,349
Number of sextant angles	168
Number of readings of compass	133
Number of lines of soundings run with small boats	30
Number of casts of the lead from small boats	633
Number of miles run by steamer on general duty	1,885

LAKE ST. CLAIR.

On the 8th of September, all the parties in Lake Superior, with the exception of that under Assistant O. N. Chaffee, having returned to this city, they were reorganized for the purpose of continuing the survey of Lake St. Clair.

The following were the assignments made:

Brevet Lieutenant F. U. Farquhar, in charge of the party on board the steamer Ada, was directed to make a survey of the delta, commencing at Point au Trembles and extending from thence to the southward and eastward as far as practicable.

Lieutenants Mally and Rogers, and Assistant Lamson and E. S. Wheeler were assigned to this party.

Colonel Farquhar was directed to make a minute survey of the old dredged channel, as well as of the locality of the new channel now being cut through the flats.

The party remained in the field until the 24th of October, having nearly completed the survey of the delta.

First Lieutenant James F. Gregory was assigned to the charge of the party on board the steamer Search, and directed to make a minute topographical and hydrographical survey of the east shore of the lake, commencing at the head of the Detroit River. He was aided by Lieutenants Griffith and Haupt, and Assistant Marr. The party closed their field operations on the 31st of October, having done the following work:

Number of primary triangulation stations built	2
Number of sounding stations	25
Number of theodolite pointings	1,064
Number of theodolite readings	1,648
Number of square miles of off-shore hydrography	4
Number of compass readings	13
Number of buoys placed out and located	39
Number of base lines measured	1

Number of miles shore-line run	7½
Number of lines sounded by small boats	103
Number of casts of lead from small boats	3,322
Number of square miles of topography	8½

Assistant J. R. Mayer and J. Paul Mayer were directed to commence work at Point au Trembles and continue to the south and west until their work met that of Assistant Molitor.

Assistant Albert Molitor, aided by Assistant F. M. Towar, was directed to begin surveying at the head of the Detroit River and work to the north and west, until he closes with the work of Assistant Mayer.

The above named parties completed the duty assigned them on the 17th of October, when they were conveyed to this city and the employés paid off and discharged.

The field-work of these parties in Lake St. Clair was as follows:

ASSISTANT MAYER'S PARTY.

Number of secondary triangulation and sounding stations built	57
Number of buoys placed and located	37
Number of theodolite pointings	1,318
Number of theodolite readings	1,492
Number of miles of soundings run	282
Number of lines sounded	223
Number of casts of the lead	8,640
Number of square miles of hydrography	34
Number of miles of shore-line run	28½
Number of miles run with stadia	58½
Number of square miles of topography	38
Number of base lines measured	2
Number of meridian lines determined	1

ASSISTANT MOLITOR'S PARTY.

Number of secondary triangulation and sounding stations built	131
Number of buoys placed and located	86
Number of lines of soundings run	421
Number of miles of soundings run	142
Number of casts of the lead	22,393
Number of theodolite pointings	1,314
Number of theodolite readings	1,985
Number of sextant angles	33
Number of vertical angles	26
Number of miles measured with chain	54
Number of miles shore-line run	21
Number of miles measured by stadia	15
Number of compass readings	194
Number of square miles of hydrography	23
Number of square miles of topography	19
Number of observations on Polaris	4
Number of camps established	2

First Lieutenant E. H. Ruffner, Corps of Engineers, and Assistant O. B. Wheeler and G. Y. Wisner, were in charge of astronomical parties organized for the purpose of continuing the astronomical observations in Lake Superior, and at the same time to read the angles of the primary triangulation. When these parties were organized, it was supposed that

three 20-inch theodolites which had been ordered for the survey from the manufactory of Messrs. Oertheig & Sons, of Berlin, Prussia, any which the makers had promised to have finished by the first of April, would arrive in time for use during the season.

Three years had been consumed since the correspondence in regard to them commenced. Careful drawings had been prepared, and the promise of the manufacturers that they should be ready was relied upon, though no definite information as to the progress of their construction could be obtained. This state of affairs continued until the 23d of May, 1868, when I recommended that the parties should be assigned to the duty of determining the latitude and difference of longitude of the chain of the lower lakes between Ogdensburg and Detroit.

My recommendation having been approved by the department, they were engaged on that duty during the season.

The points occupied were as follows: Ogdensburg, New York; Watertown, New York; Oswego, New York; Rochester, New York; Buffalo, New York; Dunkirk, New York; Erie, Pennsylvania; Ashtabula, Ohio; Cleveland, Ohio; Sandusky, Ohio; Toledo, Ohio; Monroe, Michigan; Detroit, Michigan.

The computations rendered necessary by so extended a series of observations could not be completed in season for this report. The results will be given as soon as they can be obtained.

The computations are not in progress at this time, as the parties are now engaged in the field.

LOCAL SURVEYS.

Special instructions from the Engineer Department were received during the season calling for minute local surveys of the dredged channel at St. Clair Flats, the dredged channel in Lake George, St. Mary's River, and I was also directed to turn over a party to General Cram for the purpose of making a survey, under his immediate orders, of the channel at the Neebish Rapids, St. Mary's River.

A request was also received from General T. J. Cram, engineer in charge of harbor works, for a local survey at Rains Island, St. Mary's River.

The dredged channel at St. Clair Flats being within the district assigned to Lieutenant Colonel Farquhar, under date of September 8, the survey of that point was included in the work of the party on the steamer Ada, and a map of this locality was forwarded to the Engineer Department on October 23, 1868.

The survey of the channel in Lake George was assigned to the party under Assistant O. N. Chaffee, and the work was done after the completion of his duties near White-fish Point.

A map showing the condition of the work, and also the changes that have taken place, was furnished General Cram on January 23, 1869.

The survey of the Neebish Rapids was made by Lieutenants B. D. Greene and L. M. Haupt, they having been directed to report with the party under their charge to General Cram for that purpose.

As this survey was made under the immediate orders of General Cram, it is my province only to report the fact that the party was temporarily trasferred for the purpose of making it.

The survey at Rains Island was made by Assistant O. N. Chaffee after completing his work on Lake George.

A copy of the map was furnished General Cram when completed.

GAUGING THE OUTFLOW OF THE LAKES.

Assistant D. Farrand Henry was in charge of the parties engaged in determining the outflow of the several rivers forming the connecting links in the great chain of the north and northwest lakes.

The parties were as follows: Assistant David Wallace, on the St. Clair River; Assistant Lewis Foote, on the Niagara River; Assistant A. R. Flint, on the St. Lawrence River.

Assistant Henry has applied the magnetic telegraph for transmitting signals between the ends of his base line when using floats for determining the velocity of the current, and also for the purpose of recording the revolutions of the current meter when the meter was used. His use of this agent possesses the merit of great simplicity; is believed to be entirely new, and to produce results unattained by the methods previously used.

Assistant Henry's report, herewith attached, marked Appendix A, explains in full the methods he employs, and the results as far as attained.

He is continuing his observations during the present season.

OFFICE WORK.

The usual office duties have been carried on during the entire year.

Assistant J. U. Mueller has been engaged making a reduction of the middle portion of Lake Superior, from Grand Island Harbor to Ontonagon, and extending across the lake so as to include Isle Royale and the north shore. The map is being drawn on a scale of $\frac{1}{400000}$, in the best manner, and is intended to be the second of a series of three sheets on the same scale, which together will cover the entire lake.

Mr. Mueller has also made considerable progress on Sheet No. 1 of the above series, being a chart of the eastern portion of Lake Superior, from the falls of St. Mary's River westward to Grand Island Harbor. Work on this last named chart is for the present suspended, until the primary triangulation in this portion of the lake (which has been delayed owing to the non-arrival of instruments) can be completed.

Assistant Edward Molitor has completed an engraving on stone of a preliminary chart of the east end of Lake Superior, from Sault Ste. Marie to Grand Island. This chart, like the one of the middle portion of the lake, issued last year, is only intended to meet the wants of commerce until the finished and more perfect charts of the same region can be drawn and engraved.

The demand for them both has been ample testimony to the wisdom of the policy of giving the results of the survey to the public as soon as practicable after they are obtained.

Mr. Molitor has also been engaged in the final reduction and projection of a map, on a scale of $\frac{1}{120000}$, of Isle Royale, and a portion of the north shore of Lake Superior.

Assistant O. N. Chaffee was employed during the winter, reducing for the engraver the detailed charts of the survey of Huron Bay and Huron Islands. The reduction was made on a scale of $\frac{1}{30000}$, and the chart when published will enable vessels to seek shelter in this fine harbor, of which at present the lake pilots have little or no knowledge.

Lieutenant L. M. Haupt was engaged making a general map of the entire chain of lakes, on a scale of $\frac{1}{1200000}$, and had made good progress up to the 1st of February, 1869, when he was relieved from duty on the lake survey and ordered to Texas, and, in consequence, further work on the map had to be suspended.

METEOROLOGICAL DEPARTMENT.

The meteorological observations at the twelve lake survey stations have been continued throughout the year, and the reductions and computations incident thereto have been made in the office under the immediate supervision of Assistant D. Farrand Henry. In order to reduce the volume of this report, only the means, &c., are herewith presented. The reduced detailed observations are retained in this office, and can be referred to or produced at any time.

CHART DISTRIBUTION.

The distribution of the lake survey charts has been continued both at this office and at Buffalo throughout the year. A table is given showing the number of each kind disposed of during the year, and also a tabular statement of the number for the different years, since the distribution commenced. A glance at these tables will show the growing demand for the information furnished by the survey.

SURVEY OF THE MOUTH OF MAUMEE BAY.

Just previous to starting to the field at the commencement of the present season's operations, and while the steamer Search was waiting the arrival of the long-expected instruments from Europe, which were then known to be in the country, I received an order from the Engineer Department to have an examination made of the channel into Maumee Bay. As the party was organized, no preparations were required but to get up steam. The steamer left at once, (May 26,) Lieutenant Jas. F. Gregory in charge. The duty occupied ten days' time, the party returning to this city on the 5th of June. One of the assistants was left in the office to plot the work, which was done, and the map forwarded to the bureau, and a copy of the same to Major McFarland, on the 17th of June, 1869.

INFORMATION FURNISHED.

In addition to the maps of the channel in Lake George, the Neebish Rapids, Rain's Island, and the dredged channel at the St. Clair Flats, already mentioned as having been prepared and furnished, copies of the following manuscript maps were furnished from this office by special orders from the Engineer Department, or on application of the parties to whom furnished, viz:

Map of the harbor of Cleveland, Ohio; map of the harbor of Grand River, Ohio; map of the harbor of Ashtabula, Ohio; map of the harbor of Conneaut, Ohio; map of the harbor of Black River, Ohio; map of the harbor of Sandusky, Ohio, furnished Major McFarland, Corps of Engineers. Map of portion of Lake Superior off the portage, furnished J. H. Forster, Esq., State engineer.

Return of charts issued at Detroit and Buffalo from July 1, 1868, *to June* 30, 1869.

Charts.	1868. July.	1868. August.	1868. September.	1868. October.	1868. November.	1868. December.	1869. January.	1869. February.	1869. March.	1869. April.	1869. May.	1869. June.	Total of each.
Lake Erie	9	38	23	18	7	3	1	2	3	28	24	31	187
West end of Lake Erie	9	38	22	14	7	3	1	2	4	27	25	33	185
Kelly's and Bass Islands	9	37	24	11	5	3	1	2	3	24	23	26	168
Straits of Mackinac	7	35	24	10	7	3	1	3	4	25	23	31	173
East Neebish Rapids	5	25	21	5	3	2	1	2	2	21	16	20	123
Head of Green Bay	7	31	22	8	3	2	2	2	4	29	13	22	145
Saginaw River	10	38	26	10	5	3	1	2	4	24	22	33	178
St. Clair Flats	12	39	22	14	4	4	1	2	3	28	23	31	183
Buffalo Harbor	10	35	22	11	5	3	1	3	3	25	21	28	167
Tawas Harbor	10	34	25	11	5	3	1	2	3	25	19	28	166
Beaver Group	8	34	23	9	4	2	1	2	5	30	17	31	166
Eagle Harbor	6	25	23	5	5	1	1	2	2	21	15	20	126
Agate Harbor	6	24	22	5	3	1	1	2	2	21	13	20	120
River Ste. Marie, No. 1	6	24	24	5	3	2	1	2	3	21	15	23	129
River Ste. Marie, No. 2	6	24	24	5	3	2	1	2	2	21	16	24	130
Maumee Bay	11	36	25	11	6	5	1	2	3	25	22	27	174
Eagle River	6	24	23	5	3	1	1	2	2	21	13	19	120
Ontonagon Harbor	6	26	24	6	4	1	1	2	2	22	14	19	127
Saginaw Bay	11	38	26	13	7	3	1	3	4	26	17	5	154
Thunder Bay	11	39	25	13	6	3	1	2	3	24	22	30	179
Marquette Harbor	6	26	22	6	4	1	1	2	2	22	15	20	127
Presque Isle and Middle Island	11	36	25	13	6	3	1	2	4	24	24	30	179
Lake Huron	11	43	29	14	8	4	1	3	3	27	27	39	209
South end of Lake Huron	11	40	26	13	6	3	1	2	3	24	23	28	180
Grand Island	8	28	25	8	4	1	1	2	2	26	16	23	144
West end of Lake Superior	8	30	26	9	5	1	1	2	2	28	24	28	164
Grand and Little Traverse Bays	16	46	35	23	7	2	2	3	5	52	43	40	274
North end of Green Bay	15	54	35	21	7	2	2	3	4	54	42	38	277
Copper Harbor	9	30	27	10	8	1	1	2	2	31	22	26	169
L'Anse and Keweenaw Bay	9	31	27	10	9	1	1	2	2	30	22	27	171
Portage Lake	10	31	28	10	8	1	1	2	2	31	25	29	178
Lake Superior, No. 1	...	...	...	...	...	...	...	...	2	39	32	36	109
Lake Superior, No. 2	...	15	18	3	1	2	2	1	2	40	32	37	153
North end of Lake Michigan	...	...	...	...	...	...	...	6	10	95	45	44	200
Total in each month	279	1,054	793	329	168	72	36	75	106	1,011	765	946	5,634

Table showing the annual issue prior to July 1, 1869.

Prior to October 1, 1857	2,500
October 1, 1857, to October 1, 1858	1,675
October 1, 1858, to October 1, 1859	2,600
October 1, 1859, to October 1, 1860	4,890
October 1, 1860, to October 1, 1861	3,254
October 1, 1861, to October 1, 1862	5,245
October 1, 1862, to October 1, 1863	4,084
October 1, 1863, to October 1, 1864	3,283
October 1, 1864, to October 1, 1865	2,579
October 1, 1865, to October 1, 1866	2,092
July 1, 1866, to July 1, 1867	5,464
July 1, 1867, to July 1, 1868	6,354
July 1, 1868, to July 1, 1869	5,634
Total to July 1, 1869	49,654

SEASON OF 1869.

As the season approached for resuming field operations, I found myself greatly embarrassed by the large diminution that had occurred in the available force of the survey.

Brevet Lieutenant Colonel Farquhar was, in the month of November, relieved from my command and assigned to the charge of constructions of harbors on the east side of Lake Michigan.

Second Lieutenant Louis M. Haupt was relieved in January, and ordered to Texas.

First Lieutenant B. D. Greene, and Second Lieutenant Joseph E. Griffith, were both relieved in April.

Second Lieutenant Wm. E. Rogers was assigned to the charge of the recruiting depot in this city, and thus rendered unavailable for the field.

Assistants O. N. Chaffee, Henry Gillman, and Albert Molitor, all tendered their resignations before going into the field.

Thus I was at once, as it were, deprived of the services of eight of my most experienced assistants.

It has always been my aim to so organize each party, that in case its chief should be removed or become incapable of attending to his labors, the duties of the survey would not be suspended or materially retarded; that is, to have two persons in each party capable of conducting the work assigned to it. The distant and inaccessible localities in which the survey has been carried on caused the adoption of this rule, and numerous instances have occurred, by an officer being relieved while in the field or before the work of his party was computed and projected, or by sickness or otherwise, when the necessity of the rule has been made apparent.

I found, however, that it would be impossible to effect such an organization for the present season. I know of no school other than the survey, where the experience requisite to take charge of a party can be obtained. I was therefore obliged to organize with the force at my command, and it was only because the funds available for the present year were less than two-thirds the amount applicable to last year's work, and consequently the operations were to be on a greatly reduced scale, that I was able to effect an organization in the least satisfactory.

Instead of three steamers, five shore parties, three astronomical parties, and three river parties in the field, the force this year is reduced to two steamers, two shore parties, six astronomical parties, and two river parties. The increase in the number of astronomical parties was rendered necessary to compensate for the loss of last season's work, due to the want of instruments.

The remarkably unfavorable spring caused a late departure for the field. The parties left this city as follows:

The steamer Ada, First Lieutenant J. C. Mallery, Corps of Engineers, in charge, having on board the topographical and hydrographical parties, under charge of Assistants J. R. Mayer and A. C. Lamson, sailed on the 26th of May, 1869.

The river gauging party, under charge of Assistant Lewis Foote, left for Youngstown, New York, on June 3, 1869.

The river gauging party, under charge of Assistant D. F. Henry, left for St. Clair, Michigan, on June 5, 1869.

The steamer Search, First Lieutenant James F. Gregory, Corps of Engineers, in charge, having on board the astronomical and triangulation parties, under charge of Assistants O. B. Wheeler, G. Y. Wisner, G. A. Marr, and A. R. Flint, sailed on the 6th of June, 1869.

The astronomical and triangulation parties, under charge of First Lieutenant E. H. Ruffner, Corps of Engineers, and Assistant E. S. Wheeler, left this city on June 8, 1869.

Their respective fields of operations are as follows:

First Lieutenant James F. Gregory, Corps of Engineers, was assigned to the command of the party on board of the steamer Search, for general off-shore duty, and to move and supply the primary triangulation and astronomical parties, and also to exercise general supervision over the parties in the field.

First Lieutenant E. H. Ruffner, Corps of Engineers, was assigned to the command of the three primary triangulation and astronomical parties in the western part of the lake, having himself the immediate charge of one division, and Assistants G. Y. Wisner and E. S. Wheeler to take charge of the other two sections.

First Lieutenant J. C. Mallery, Corps of Engineers, was assigned to the command of the party on board the steamer Ada, for off-shore duty

near and around the Apostle Islands, and also to survey the outer islands of the group connecting with the work of the shore parties.

Assistant J. R. Mayer was assigned to the command of a shore party, commencing work at the most eastern point reached by the survey of the "head of the lake" in 1861, and continue east to meet Assistant Lamson, making also a survey of the western Apostle Islands.

Assistant A. C. Lamson was assigned to the command of a shore party, to commence work at the most western point reached by Lieutenant Griffith's party in 1868, and to continue west to meet Assistant Mayer, making also a survey of the eastern Apostle Islands.

Assistant D. F. Henry was assigned to the command of the parties to continue the gauging of the rivers.

Assistant O. B. Wheeler was assigned to the charge of the three divisions of the astronomical and primary triangulation parties in the eastern portion of the lake, having for chiefs of divisions Assistants A. R. Flint and G. A. Marr.

On the 5th of June, 1869, Brevet Major Jared A. Smith, United States Army, captain Corps of Engineers, reported for duty as my senior assistant. He was at once sent into the field as the immediate chief of the party on board the steamer Ada, and given a general supervision of all field operations, with instructions to issue such orders in my absence as he might find requisite to insure uniformity in the work and the faithful performance of the duties of the survey.

At the date at which this report commences all the parties were at their posts, and busily engaged in the discharge of their respective duties.

I may add that I visited the parties myself in July and also in August. They were only making tolerable progress, the season having been by far the worst for field operations ever known in the history of the survey. I think it probable that the shore-line and detailed topography and hydrography of Lake Superior will be finished the present season, but that a portion of the primary triangulation and general hydrography will remain incomplete.

Respectfully submitted.

W. F. RAYNOLDS,
Lieut. Col. of Engineers, Bvt. Brig. Gen.

Bvt. Brig. Gen. A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers, Washington, D. C.

The following is an estimate for continuing the survey of the northern and northwestern lakes for the fiscal year to commence July 1, 1870, *and end June* 30, 1871, *on the same scale and with a similar organization to that employed during the season of* 1868:

For three parties for hydrographical duty, general triangulation, reconnoissance, &c., one for each of the lake survey steamers Search, Surveyor, and Ada, the cost of each party will be as follows:

1 assistant, 183 days, at $4 80 per day	$878 40
1 assistant, 183 days, at $3 60 per day	658 80
1 assistant, 183 days, at $2 50 per day	457 50
1 recorder, 183 days, at $1 25 per day	228 75
1 sailing master, 365 days, at $2 75 per day ..	1,003 75
1 mate, 183 days, at $2 per day	366 00
1 steam engineer, 365 days, at $2 75 per day ..	1,003 75

1 assistant engineer, 183 days, at $2 per day	$366 00	
1 carpenter, 183 days, at $2 per day	366 00	
1 steward, 183 days, at $1 50 per day	274 50	
1 cook, 183 days, at $1 50 per day	274 50	
1 second cook, 183 days, at $1 per day	183 00	
4 firemen, 183 days, at $1 25 per day	915 00	
14 seamen, 183 days, at 90 cents per day	2,305 80	
Subsistence for the above 30 persons, 183 days, at 50 cents each per day	2,745 00	
450 tons coal, at $8 per ton, (for fuel)	3,600 00	
Total for one hydrographical party	15,626 75	
For three hydrographical parties		$46,880 25

For three astronomical, magnetic, and primary triangulation parties as follows:

1 assistant, 183 days, at $4 80 per day	$878 40	
1 assistant, 183 days, at $2 50 per day	457 50	
1 recorder, 183 days, at $1 25 per day	228 75	
1 cook, 150 days, at $1 50 per day	225 00	
5 men for boats' crews and laborers, 150 days, at 80 cents per day	600 00	
Transportation of parties, provisions, camp equipage, &c., to and from the field	500 00	
Subsistence for 9 men, 150 days, at 50 cents per day	675 00	
Total for one party	3,564 65	
For three parties		10,693 95

For five topographical and hydrographical parties to survey shore-line and adjacent topography and hydrography, the cost of each party will be as follows:

1 assistant, 183 days, at $4 80 per day	$878 40	
1 assistant, 183 days, at $3 60 per day	658 80	
1 recorder, 183 days, at $1 25 per day	228 75	
1 foreman, 165 days, at $1 40 per day	231 00	
1 steward, 165 days, at $1 40 per day	231 00	
1 cook, 165 days, at $1 40 per day	231 00	
1 waiter, 165 days, at $1 per day	165 00	
2 leadsmen, 165 days, at 90 cents per day	297 00	
2 chainmen, 165 days, at 80 cents per day	264 00	
14 boatmen, 165 days, at 70 cents per day	1,617 00	
Subsistence of above 25 persons for 165 days, at 50 cents each per day	2,062 50	
Expenses in purchase of tools, buoys, flags, rope, leads, lead lines, materials for stations, camp and mess equipage, &c	600 00	
Transportation of 25 men to and from the field, at $20 each	1,000 00	
Expenses of transportation of provisions, camp equipage, &c., to and from field, at $250 each way	500 00	
Total for one party	8,964 45	
For five topographical and hydrographical parties		44,822 25

For three parties for gauging the outflow of rivers, the expense of each will be as follows:

1 assistant, 183 days, at $3 60 per day	$658 80	
1 recorder, 183 days, at $1 25 per day	228 75	
6 men, 165 days, at $2 per day, including board	1,980 00	
Board of 1 assistant and 1 recorder, 165 days, at $1 per day	330 00	
Transportation to and from the field	300 00	
Total for one party	3,497 55	
For three parties for gauging outflow of rivers		$10,492 65

Office and miscellaneous expenses:

Office rent and fuel for one year	$1,800 00	
Pay of two draughtsmen for reducing maps for engraving, one year of 365 days, at $5 30 each per day	3,869 00	
4 assistants, chief of parties, 182 days, at $5 30 per day	3,858 40	
5 assistants, 182 days, at $4 10 per day	3,731 00	
2 assistants, 182 days, at $3 50 per day	1,274 00	
1 assistant, 365 days, at $4 10 per day	1,496 50	
1 assistant, 365 days, at $3 per day	1,095 00	
3 copyists and computers, 365 days, at $2 30 each per day	2,518 50	
1 office attendant, 365 days, at $1 50 per day	547 50	
3 steamers in ordinary, at $1,000 each	3,000 00	
Commutation of fuel and quarters for 5 officers of the Corps of Engineers	2,750 00	
Traveling expenses of superintendent and assistants while attending to the duties of the survey	750 00	
Expenses in office, drawing paper, and materials, stationery, nautical almanacs, &c	600 00	
Expenses of meteorological and tide-gauge observers for one year	4,000 00	
Total estimate for office and miscellaneous expenses		31,289 90
Add 10 per cent. to cover contingent and other expenses, such as purchase of tools, boats, camp equipage, &c		14,417 90
Total estimate		158,596 90

Respectfully submitted.

W. F. RAYNOLDS,
Lieut. Col. of Engineers, Bvt. Brig. Gen.

A.

OFFICE LAKE SURVEY, *July* 1, 1869.

SIR: I have the honor to submit the following report of the progress made by the river-gauging parties under my charge during the past year:

Before the close of the season of 1867, I began to have great doubt of

the correctness of the results obtained by means of floats, on account of the unavoidable errors of that method.

These errors may be classed under the following heads:

1. *The error of the area of cross-section.*—In order to obtain the true area it would be necessary to know the exact depth of the river past the whole base line. Generally we sound out two or three cross-sections carefully, and assume their mean to be the mean area of the river. Then, finding the mean time of passage of floats past the base line, the velocity of the river is obtained, and the product of this into the mean area has to be taken as the true discharge. I noticed that in the places chosen, which were the best that could be found, that the irregularities of the bottom were such that the product of the mean velocity into the area of the river, at the upper and lower end of the base, would make a difference of several thousand cubic feet per second, and I was obliged to take the mean as the discharge, though I knew that it could not be correct. Again, the irregularities of the bottom affect the current, and the floats are differently influenced at different depths, so that, although the computed discharge might happen to be correct at one depth, it would not be so at another.

2. *The irregularities of flow.*—These, together with the irregularities arising from the form of the bottom, are shown, by the fact noticed in the last report, that often when two floats were put out at different depths, say five and ten feet, the rear one would gain upon and sometimes even overtake the forward one. This sometimes happened when the floats were at the same depth, but not often. These irregularities make the determination of velocity very uncertain, and a very large number of observations would be necessary to give an approach to accuracy.

3. *The difficulty and uncertainty of the location of the floats.*—The length of the base lines were one-third the distance of the furthest float from them, and the stations were connected by telegraph, so that the time of passage of the float past one station was instantaneously communicated to the observer at the other. But when a float was moving at a rate of over two feet a second, it was impossible to follow it with the telescope by means of the tangent screw, so that the instrument had to be moved by hand, and it was only by a lucky chance that the hairs were brought exactly on the float when the signal came. This made an uncertainty in the location; and, as the velocity is slower near the banks, the computed velocity would be too large or too small, as the error was on one side or the other. Again, the floats rarely ran in the same vertical plane or parallel to each other. Often in still weather, when the boat was anchored near the center of a division, part of the floats would run out of the division altogether, or more than one hundred feet out of their proper plane, the calculated path of the float being sometimes as much as three feet longer than the distance between the cross-sections. This would, of course, be a cause of error, when we attempted to reduce them to the center of the section to obtain the mean velocity.

4. A floating body moves faster than the water in which it is immersed. Navier has investigated this subject, and gives a formula for the computation of the error. It depends upon the slope of the surface, the displacement of the body, and area of its greatest transverse section. Its amount, however, is small and not worth the trouble of computing.

5. The upper float drags the lower. This is also small, and depends upon the relative sizes of the floats and velocity of current.

6. The upper and lower floats are connected by a cord one-twelfth in diameter. This also drags the lower float an amount in direct proportion to the length and size of the cord. But the cord can never be perfectly

straight; it must bend down stream, and, therefore, raise the lower float. This is also in proportion to the length and size of the cord. This raising of the lower float brings it into a faster current, and, therefore, gives too large velocities as we approach the bottom.

In putting out the floats from the boat they cannot both be thrown out at once without danger of tangling the cord, but the upper one must be held until the lower has gone far enough to keep the cord extended.

Now, the upper float must go enough faster to gain its proper position over the lower before they reach the upper section, otherwise it will run through too fast. Whether it does or not can only be guessed at, and the distance required for the two floats to assume their relative positions will depend upon the length of the connecting cord and their velocity.

Again, when the floats are in their proper relative position they cannot be vertically over one another; but the cord must form the curved hypothenuse of a right-angled triangle, of which the perpendicular is the true depth of the lower float, and the base varies according to the depth, velocity, and relative size of the floats and cord. This also would give the velocity too fast.

Of these errors the first three are uncertain and the last three are always plus; but the sixth appears to be the most important and the most difficult to calculate and eliminate.

These errors, so numerous and so complicated, made me despair of ever being able to obtain the true velocity by means of floats, and forced me to turn to the other methods used by eminent hydraulic engineers in their determinations of the laws for the flow of water. These are principally floating tubes used in canals and feeders so successfully by Mr. J. B. Francis, in the Lowell hydraulic experiments, but which would be too cumbersome for deep rivers:

Pétots's tube, modified by M. Darcy, the most correct instrument ever devised for shallow measurements, but which needs a firm resting place to be used accurately. Brünning's pressure plate, with which he obtained excellent results on the Rhine, but which, in these deep and wide rivers, would be more difficult to use. Woltmann's meter, which is excellent as far as it goes, but it is inconvenient to use, as it has to be raised and lowered at each observation. Borda's wheel, which is a float wheel with a long screw passing through the axle, the number of revolutions being found from the length of the screw passed over; perhaps the most ingenious of all forms of meters, and running with a minimum of friction, but only for a limited time; it was intended only for surface velocities, but was modified by M. Laignel so as to be used at any depth. Lapointe's meter, where the wheel is inclosed in a tube and the train elevated above the meter, thereby increasing the friction, and rendering it only useful in measuring the discharge of reservoirs and the flow of shallow streams. Saxton's meter, which has less friction than Woltmann's, as it has but one gear wheel to record the revolutions, but the time it can be run without raising it is proportionately lessened.

None of these fulfilled the conditions required; but if a meter could be made to record separate from the wheel, then the friction would be reduced to a minimum and it could run for an indefinite time. This I accomplished by attaching the wires of a battery to the meter, so that every revolution of the wheel the electric current would be broken.

Now when a Morse register was placed in the circuit, every revolution of the wheel would make a dot on the moving paper, and from the number of these recorded in a given time the velocity of the current was easily computed. This was sometimes used, but commonly the

number of revolutions was obtained by means of a tell-tale, attached to an ordinary sounder or relay.

The forms of the meters are given in Figs. 1 and 2, and the register is shown in Figs. 3 and 4.

Fig. 1 is a float meter, the cups of a Robinsen's anemometer being hung in a frame between pivots. An arm is fastened to the axle, and at every revolution of the cups it comes in contact with a fine silver wire, which is bent spirally to give it more elasticity. This wire is insulated from the frame, and is connected with one of the battery wires, the other being attached to the frame. The frame is hung in a yoke, and back of it are vanes to keep the cups in the direction of the current as shown in Fig. 5.

Fig. 2 shows one form of propeller used—a modification of a Saxton's meter. An eccentric is placed on the hub of the wheel, on which a roller at the end of an ivory lever is kept by means of an adjustable spring. This lever has a platinum wire in it, which projects at the bottom, where it is kept in contact with a platinum plate on the axle, when the eccentric is at its minimum. This wire is hinged into one of the battery wires, insulated from the meter, and the other battery wire is connected with the axle. This meter has also a supporting yoke and vanes at right angles, not shown in the drawing.

Figs. 3 and 4 show a front and back view of the register used. This consists of a simple telegraphic sounder with an escapement lever attached to the armature arm, the pallets being so arranged that they just pass the center of the first gear-wheel, so that each time the armature rises and falls, the gear-wheel advances one tooth. The front wheel contains one hundred teeth and has a ten-leaved pinion on its axle, with which the second wheel of one hundred teeth engages, thus registering one thousand double movements of the armature, which are shown by the hands on the dials. When the register is put into an electric circuit with the meter, as each revolution of the meter wheel breaks and closes the circuit, the armature will rise and fall at the same time, and thus each revolution is recorded, and can be read by means of the hands on the dials.

The method of using the apparatus is shown in Fig. 5. A boat is provided with an ordinary anchor, and a weight for anchoring the wire. One line about two hundred feet long is fastened at the fluke end of the anchor stock, and another into the ring. Rowing out into the stream about two hundred feet above where the current is to be measured, the anchor is thrown overboard, and the boat dropped back, till we come nearly to the end of the line fastened to the ring of the anchor. This end is now made fast to the front ring of the weight, and another line and a strong copper wire are fastened to the upper ring. The weight is now lowered, and the boat dropped back at the same time, till the weight is vertically under the stern of the boat.

The anchor line is made fast in the bow, and the line fastened to the weight is left slack, so that it will be out of the way, and fastened to the stern.

The spring-pole, which runs fore and aft the boat, is now bent down and the copper wire fastened to the after end. This serves to keep the line always taut, and also to take up small motions of the boat.

The yoke in which the meter frame hangs has a swivel ring at top and bottom. To the upper one is attached a measured cord, having spring clasps every five feet, and to the under one is fastened a weight.

There are two eyes in the side of the yoke, which are passed over the copper or standing wire, and on which they slide up or down. The

meter being put on the wire, it is lowered to say five feet depth, and the ends of the standing wire and of the insulated wire connected with the battery and register in the boat; each revolution is recorded by the register.

By means of a switch the register can be thrown in or out of circuit in a moment, and the number of revolutions in any given time found.

The meter can be now lowered to any other depth, by means of the measured cord, which is fastened to the wire by the clasps to keep it as nearly perpendicular as possible, and the revolutions found; and so on until the requisite number of observations have been taken at that position.

The position of the boat can be exactly determined by a theodolite on shore.

After having furnished the required observations at one place, we first let the upper end of the standing wire loose, and then pull up the weight by the lines fastened to it, and by means of the connecting line the forward anchor is very easily raised even from clay bottom, as it is fastened to the upper end of the stock, and this lifts the anchor directly.

Assistant A. R. Flint devised the break used on the float meter, the only friction being that of the axle on the steel points, and the striking of the arm against the fine silver wire. In the faster moving propeller wheels this method was not practical, as the time the wires remained connected was too short to allow the register to work, so that with them we had to use a longer break which gave a little more friction, and therefore they required a little faster current to turn them.

By the use of the meter we eliminate all the errors heretofore mentioned, which are inherent to the method of float measurement; for, the base being reduced to a point, only one cross section is needed, and as the meter is free to move in all directions it will give the velocity of any current, no matter at what angle it passes the plane, and the discharge at that point must be equal to the mean of all the velocities past the plane into the area of the cross section. The irregularities of the current can also be eliminated by letting the meter run a sufficient time; and its superiority over the floats is seen in the fact, that while the float is but a moment passing any plane, and therefore will only give the velocity of the current at that moment, the meter can be run for any required time, and will give the mean velocity for the whole period. One hundred and fifty floats in a day is about as many as a single party can put out and locate; the mean of the day's work will give the velocity for, say, one hundred and fifty seconds, while from the meter we can obtain it for the whole time or any part thereof. The other errors of the floats do not of course affect the meter. The determination of the coefficient seems to be the only possible error to which we are liable in the use of the meters.

For this, therefore, careful experiments were made by drawing them through still water, and these results were also tested by comparisons with floats.

COEFFICIENT OF METERS.

This was found by fastening the meters about three feet below the center of a small boat, and then drawing them across a pond about five hundred feet wide.

The boat was drawn at different velocities, the number of revolutions of the meter and the time of passage being recorded.

The distance traveled being divided by the number of seconds, the velocity in feet per second was determined.

Then the number of revolutions per second were grouped for each half foot of velocity per second, as shown in the following table:

TABLE I.—*Showing the number of revolutions per second for each half foot of velocity for the several meters.*

Velocity in feet per second.	Revolutions per second.		
	Float meter.	Saxton No. 2.	Saxton No. 3.
0.3			
0.5	0.0391		
1.0	0.0900	0.558	0.440
1.5	0.1461	0.872	0.696
2.0	0.2057	1.213	0.959
2.5	0.2715	1.514	1.223
3.0	0.3375	1.897	1.494
3.5	0.4050	2.229	1.761
4.0	0.4657	2.635	2.034
4.5	0.5292	2.947	2.296

These quantities appear to follow some general law of increase approximating to a straight line, but to obtain the coefficient of the meter it is necessary to divide severally the velocities per second by the revolutions per second.

This is done in the following table under the head of observed coefficient:

TABLE II.—*Showing the comparison of the observed and computed revolutions and coefficient for the several meters.*

Velocity in feet per second.	Ordinates of curve.	FLOAT METER.					SAXTON NO. 2.					SAXTON NO. 3.				
		Revolutions.		Coefficient.			Revolutions.		Coefficient.			Revolutions.		Coefficient.		
		Observed.	Computed.	Observed.	Computed.	Difference.	Observed.	Computed.	Observed.	Computed.	Difference.	Observed.	Computed.	Observed.	Computed.	Difference.
0.3	0.000	0.000	......	......	14.573	......	......	......	......	......	......	......	......	......	......	......
0.5	0.431	0.0391	0.0394	12.778	12.704	+0.074	......	......	......	......	......	0.000	......	......	2.390	......
0.65	0.694	......	......	......	......	......	0.000	......	......	1.880		......	......	......	......	......
1.0	0.961	0.0900	0.0894	11.123	11.190	—0.067	0.558	0.573	1.757	1.744	+0.013	0.440	0.446	2.271	2.282	—0.011
1.5	1.214	0.1461	0.1454	10.263	10.300	—0.032	0.872	0.896	1.680	1.673	+0.007	0.696	0.698	2.153	2.149	+0.004
2.0	1,395	0.2057	0.2070	9.722	9.662	+0.060	1.213	1.228	1.629	1.627	+0.002	0.959	0.964	2.087	2.085	+0.062
2.5	1.524	0.2715	0.2715	9.208	9.208	—0.000	1.514	1.567	1.584	1.595	—0.011	1.223	1.226	2.044	2.040	+0.004
3.0	1.617	0.3375	0.3378	8.888	8.881	+0.007	1.897	1.908	1.562	1.572	—0.010	1.494	1.494	2.007	2.007	—0.000
3.5	1.678	0.4050	0.4030	8.638	8.686	—0.048	2.229	2.252	1.550	1.556	—0.006	1.761	1.764	1.987	1.984	+0.003
4.0	1.712	0.4657	0.4681	8.589	8.546	+0.043	2.635	2.589	1.544	1.545	—0.001	2.034	2.032	1.965	1.969	—0.004
4.5	1.720	0.5292	0.5283	8.504	8.518	—0.014	2.947	2.922	1.542	1.540	+0.002	2.296	2.295	1.959	1.960	—0.001
Sums..		......	......	......	......	+0.015	......	......	......	......	—0.004	......	......	......	......	—0.003
Mean...		......	......	......	......	+0.0017	......	......	......	......	—0.0005	......	......	......	......	—0.0004

It was found, that an ellipse having a minor axis of 3.44, and major axis of 8.2, would best satisfy the condition of variation in these quantities.

In the first column of the table the ordinates of this curve for each half foot of velocity are given.

Plotting this curve and placing the vertex at the zero of the meter,

that is, at the velocity at which it begins to turn, we can by changing the scale of ordinates plot the coefficient of meters. Or let

$a =$ the assumed zero coefficient,
b_1, b_2, b_3, &c., = observed coefficient at each half foot of velocity, and
$c =$ the semi-minor axis of the ellipse,

then making $\frac{a-b_{4\cdot5}}{c} = \varphi$

we have for the different velocities

$$y_{0\cdot5} = \frac{a-b_{0\cdot5}}{x} \qquad y_{1\cdot0} = \frac{a-b_{1\cdot0}}{x}, \text{ \&c.}$$

These quantities being compared with the ordinates of the curve, a series will be found which will approximate very nearly to them.

Taking this series and dividing severally by x and subtracting the quotient from a, we have the computed coefficients given in the table, which can be compared with the coefficient as observed.

Thus we have for the float meter the assumed coefficient
of the zero .... $a = 14.573$
the common divisor x .... $= 3.528$
and the velocity of the water at the zero of the meter..... 0.3 foot.

The differences between the observed and computed coefficients given in the table are very small, and are probably mostly due to errors of observations.

M. Morin (Hydraulique, page 100 et seq.) gives certain observations for the determination of the coefficient of the Lapointe's meter, by noting the number of revolutions and corresponding time during which a reservoir of known size was being filled by water passing through the meter at different velocities.

He gives a formula for the meter of the form $Q = a + bn$, in which $Q =$ the discharge, $n =$ the number of revolutions, and $a + b$ are constants to be found by experiment.

This it will be seen is the formula of a straight line, and it agrees very well with his observations. But it is only applicable to an enclosed meter, where the area of the volume of water passing the meter is known.

I have taken his data and have found the coefficient of the meter reduced to English feet, for each half foot of velocity.

In the table below are given these observed coefficients and the coefficient as computed by the formula previously given.

TABLE III.—*Showing the comparison of the observed and computed coefficient of Lapointe's meter.*

Velocity in feet per second.	Coefficients.		
	Observed.	Computed.	Difference.
1.5		0.650	
2.0	0.571	0.572	—0.001
2.5	0.546	0.540	+0.006
3.0	0.519	0.519	0.000
3.5	0.507	0.502	+0.005
4.0	0.496	0.493	+0.003
4.5	0.486	0.485	+0.001
5.0	0.477	0.480	—0.003
5.5	0.474	0.478	—0.004
Sum			+0.007
Mean			+0.0009

It will be noticed that the coefficient differs even less from the curve than of my own meters. Beyond the velocities given in this table there are a few observations, and they plot on each side of a tangent to the ellipse drawn through the intersection of the minor axis, showing apparently that the coefficient follows a straight line in greater velocities than are given by the curve.

This meter having been tested by a measured amount of water passing it in a given time, makes this coincidence of its coefficient with the curve quite important, as it in a measure proves the corrections of the still water observations, and also the general application of this method to the computation of the coefficient of all meters, though I have not as yet been able to obtain the observations made by other engineers.

M. Morin says in this connection, "If certain engineers in using instruments of this kind have found that the relation between the velocities and number of revolutions should be represented by a curved line of the parabolic form, it comes no doubt from the fact that in the instruments they used the friction notably increased with the velocity."

But when the appliances are light and the surfaces of the blades of the screw are sufficiently large, as in the meter we have been examining, the friction will remain very small and then the number of revolutions will increase proportionally to the velocity. I also do not think that the experiments which have furnished results different from those of M. Lapointe have been as extended, nor made with a precision comparable to the observations of this engineer. As will be seen from the tables above, the Lapointe meter stops at a velocity of 1.5 foot per second, while the float meter moves at 0.3 foot per second.

M. Dubuat gives the resistance of a sphere as 0.35 of that experienced by its great circle when drawn through still water; and Beaufoy with velocities from two to twelve feet per second found the resistance to vary from 0.325 to 0.359, giving a mean of 0.342.

It was upon these results that Robinson constructed his anemometer, now so generally used in meteorological observations, in which he called the velocity of the cups one-third that of the wind moving them. Obtaining the same ratio of resistances from the observed revolution of the float meter, given in table II, we find for the mean of the whole 0.360, which is nearly the same as that above, while for the velocity of 4.5 feet per second it is only 0.189; therefore the velocities given by the anemometer when the wind is blowing over two or three miles an hour will be much too small.

To test the corrections of the coefficient, the float meter was compared with floats in a small canal at Ogdensburg, conveying water from the dam to certain mills.

A straight reach was chosen below the dam and above the mill sluices so as to have the minimum of disturbance. Wires were stretched across the canal 200 feet apart, and the time of passage of the floats past the wires was telegraphed to the recorder, who had a chronometer before him and noted the time to the nearest tenth of a second. The floats were run at mid-depth of the canal and as nearly in the center as possible, and the meter was run continuously at the same depth midway between the wires. The wind was quite strong in the direction contrary to the flow of the water in the canal during all the observations, but its force being broken by the surrounding buildings, the effect upon the floats was very small.

TABLE IV.—*Showing the comparison between the floats and meter in the canal at Ogdensburg.*

No. of observations.	Velocity of current feet per second.			Arithmeti'l sum of differences.	Mean.	Range.
	By floats.	By meter.	Difference.			
24	1.992	1.980	+0.012	2.314	0.096	+0.219 to —0.162
6	1.876	1.916	+0.040	0.368	0.061	+0.064 to —0.161
6	1.476	1.434	—0.042	0.443	0.074	+0.157 to —0.092

From this it will be seen that the difference between the mean velocity, as determined by the floats and the meter, is small, though the range of velocities, as given by single floats, is quite large.

I have not as yet been able to test the coefficient of the meter by measuring the quantity of water passing it in a given time, though the observations on Lapointe's meter, given above, seem to show the corrections of the general curve.

The following table shows the comparison between the meter and floats at different depths taken in the St. Clair River:

The floats were run past the same base line and in the same manner as in the previous year. (Report 1867–'8.)

TABLE V.—*Comparison of floats with Saxton's meter No. 2, in the St. Clair river,* 1868.

DATE.		WIND.			Depth of floats.	No. of floats at each depth.	VELOCITY.			Remarks.
Day.	Hour.	Direction.	Velocity, miles per hour.	Resultant velocity parallel to river, miles per hour.			By floats, feet per second.	By meter, feet per second.	Difference.	
Sept. 1...	11 a. m.	Calm ...	......	....	5	3	4.405	4.340	+0.065	395 feet from base.
					10	5	4.314	4.224	+0.090	
					15	5	4.218	4.081	+0.137	
					20	5	4.106	3.997	+0.109	
Sept. 1...	12 m ..	S. E.....	3	Up 2.7....	25	5	3.936	3.898	+0.038	
					30	5	3.947	3.639	+0.308	
					35	2	3.741	3.261	+0.480	Depth of river, 44 ft.
Sept. 1...	3 p. m	N. W ...	9	Down 8.0.	37	5	3.718	3.142	+0.576	467 feet from base.
					35	3	3.824	3.482	+0.452	
					30	4	4.058	3.717	+0.341	
					25	3	4.029	3.787	+0.242	
					20	3	3.996	4.032	—0.036	
Sept. 1...	5 p. m	N. W ...	12	Down 10.7.	15	5	4.196	4.080	+0.116	
					10	5	4.197	4.259	—0.062	
					5	5	4.294	4.305	—0.011	Depth of river, 44 ft.
Sept. 2...	....	....	......	....	5	3	3.144	3.228	—0.084	1,339 feet from base.
					10	3	3.239	3.216	+0.023	
Sept. 2...	11 a. m.	W. S. W	4.0	Up 0.3....	15	5	3.251	3.101	+0.150	
					20	5	3.235	2.858	+0.377	
					25	2	3.087	2.824	+0.263	
Sept. 2...	1 p. m	S	4.5	Up 4.3....	30	5	3.061	2.804	+0.257	Depth of river, 43 ft.
Sept. 2...	3 p. m	S. E.....	9.0	Up 8.0....	5	5	2.330	2.601	—0.271	1,580 feet from base.
					10	1	2.078	2.425	—0.347	
					15	5	2.174	2.258	+0.084	
Sept. 2...	5 p. m	S	8.0	Up 7.6....	20	4	2.100	1.839	+0.261	Depth of river, 29 ft.
Sept. 4...	....	....	......	....	5	2	3.916	4.119	—0.203	1,044 feet from base.
					10	5	3.929	4.181	—0.252	Observatio's not very
Sept. 4...	11 a. m.	W. S. W	10.0	Up 0.8....	15	4	3.982	4.179	—0.197	good on account of
					20	3	3.795	3.851	—0.056	the waves.
					25	3	3.803	3.694	+0.119	
					30	4	3.611	3.625	—0.014	
					35	3	3.624	3.577	+0.047	
Sept. 4...	1 p. m	W. S. W	10.7	Up 1.2....	40	5	3.551	3.343	+0.208	
					43	3	3.564	3.219	+0.345	Depth of river, 49 ft.

The meter was located midway between the sections, as near the path of the floats as possible, and run continuously at each five feet depth during the whole time the floats were passing at the same depth.

There are not enough of these observations to give the true difference between the floats and meter for all depths, and, therefore, we cannot yet reduce the observations taken in 1867, but they are sufficient to show that while near the surface in a calm the meter and floats give nearly the same velocity, while as we approach the bottom the velocity determined by floats is greater than that given by the meter; and, though the range of difference shows that a large number of observations will be required to give the law of variation, yet there are enough to show that the errors of float measurement are in the direction heretofore pointed out, and that sub-surface velocities given by the double floats will be too large.

I think that I have shown that the meter gives velocities as nearly correct as is possible with any apparatus when the coefficient is known, and that it is as accurate in the measurement of velocities at all depths as Mr. Darcy's modification of Petot's tube is in canals and small streams.

In table A, at end of report, are given the reduced meter observations for 1868. In these tables two different methods of observation are given; one for determining the vertical curve and the other for determining the horizontal.

In the first case the boat was anchored in one place long enough to allow the meter to run for any required length of time at each five feet of depth; thus occupying only a few positions in a day. In the second the meter was only run at two or three depths and then moved about two hundred feet, thus going across the whole river in one day.

These latter observations were taken to find the horizontal curve for a single day, by means of which the vertical curves taken on different days could be reduced to the center of the two hundred feet division into which the river was divided, in order to give the discharge more accurately, as noticed in the last report.

But it was found that the velocity changed as much from day to day as it did in the whole season, so that the horizontal curves were constructed from the whole observations by plotting the daily velocities obtained at each five feet of depth in their proper relative distance from the base line. A free hand curve was drawn through these points and a connection found which was applied to each observed velocity to reduce it to the center of the division in which it was taken. The velocities for Niagara vary greatly; this is due partly to the eddies and partly to the flow over the falls, hereafter noticed.

The velocities for each five feet of depth reduced to the center of each division are given in the following tables:

The surface velocities at St. Clair and Niagara were not properly taken.

The meter being at the stem of the boat the true velocity could not be obtained, as the friction of the current against the bottom of the boat would retard it very much, and, therefore, give its velocity too small. At Ogdensburg there were too few taken to be of any importance. The bottom velocities, given in the tables, were obtained by plotting the velocities on a large scale, and continuing the curve they indicated till it intersected the line representing the bottom of the river. These are probably too large.

TABLE VI.—*Showing the mean observed velocities reduced to the center of each division, St. Clair,* 1868.

Depth.	1st division. 1st half.	1st division. 2d half.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	
1	1.419	3.218	3.992	4.212	4.127	4.004	3.740	3.089	2.485	....	1
5	1.439	3.278	4.215	4.404	4.212	4.112	3.826	3.260	2.599	1.122	5
10	1.517	3.164	4.051	4.309	4.065	4.090	3.698	3.225	2.489	1.114	10
15	1.193	3.030	3.960	4.171	4.022	4.017	3.650	3.085	2.299	0.911	15
20	....	2.797	3.794	4.040	3.933	3.912	3.533	2.925	2.061	....	20
25	....	2.522	3.688	3.846	3.800	3.788	3.366	2.702	1.751	....	25
30	....	29 ft. 2.350	3.477	3.723	3.666	3.646	3.235	2.434	27 ft. 1.500	....	30
35	....	....	3.092	3.424	3.485	3.547	3.003	2.169	....	....	35
40	....	....	39 ft. 2.436	2.925	3.208	3.353	2.607	1.806	....	....	40
45	....	....	....	43 ft. 2.750	3.032	3.032	2.531	....	....	....	45
50	....	....	....	....	2.700	2.699	47 ft. 2.350	....	....	....	50
....	....	....	....	....	....	52 ft. 2.500	....	....	....	....	....

TABLE VII.—*Showing the mean observed velocities reduced to the center of each division, for Niagara River, from June* 10 *to July* 17, 1868.

CORRECTED.

Depth.	1 0–100.	2 100–200.	3 200–300.	4 300–500.	5 500–700.	6 700–900.	7 900–1100.	8 1100–1300.	9 1300–1500.	10 1500–1700.	11 1700–1850.
1	2.256	2.523	3.908	3.677	4.257	4.751	3.949	4.270	3.931	2.934	2.698
5	2.302	2.710	3.240	4.057	4.227	4.523	4.247	4.197	3.814	3.487	2.918
10	2.087	2.450	3.267	4.125	4.253	4.450	4.667	4.170	3.887	3.618	3.534
15	2.118	2.802	3.690	4.085	4.329	4.065	4.448	4.132	3.869	3.293	3.267
20	1.913	2.485	3.274	4.141	4.235	4.637	4.144	4.135	4.042	3.157	3.346
25	1.732	2.431	3.243	3.770	+ 4.137	4.247	4.091	4.169	3.710	3.082	3.468
30	0.650	2.507	3.275	3.934	4.093	4.032	3.794	3.788	3.960	3.095	1.514
35	....	2.685	3.015	3.842	4.324	3.846	3.774	3.602	3.610	2.659	1.083
40	....	2.307	3.111	3.858	3.877	3.718	3.438	3.264	3.457	2.921	0.825
45	....	1.937	2.848	3.659	3.851	3.226	3.318	2.896	2.603	1.812	....
50	....	1.439	2.587	3.377	3.407	2.850	2.650	1.900	(48-5) 1.400	(48-50) 0.960	....
55	....	0.680	2.655	3.188	3.165	1.800	(53) 2.490	....	....	....	....
60	....	....	1.968	3.085	2.660	(56) 1.620	....	....	....	....	....
65	....	....	1.582	2.833	(60-92) 2.180	....	....	....	....	....	....
Mean.	....	....	(68) 1.480	(70) 2.200	....	....	....	....	....	....	....
	....	....	....	(70-95) 2.010	....	....	....	....	....	....	....

TABLE VIII.—*Showing the mean observed velocities reduced to the center of each division, for Niagara River, from July 17 to September 17, 1868.*

Depth.	1	2	3	4	5	6	7	8	9	10	11
1–2	2.241	2.200	3.720	3.740	3.960	3.461	3.436	3.723	3.155	2.357	1.565
5	2.786	1.955	3.424	4.015	4.305	3.994	3.959	3.857	3.390	2.639	1.784
10	2.362	2.256	3.806	3.216	3.675	4.094	3.618	3.607	3.225	2.668	1.669
15	1.915	2.019	3.550	3.564	3.383	3.585	3.625	3.219	3.047	2.690	1.355
20	1.667	2.240	3.146	3.505	3.793	3.294	3.927	3.308	2.948	2.578	1.643
25	1.546	1.920	3.305	3.173	3.458	3.447	3.446	3.188	3.119	2.838	1.641
30	0.920	1.786	3.225	3.438	3.341	3.119	3.203	2.953	2.888	2.612	1.482
35	....	2.309	3.440	3.551	3.191	3.499	3.181	2.770	2.812	2.059	1.280
40	....	1.770	2.510	3.215	3.054	3.295	2.779	2.582	2.502	1.866	1.055
45	....	1.430	2.654	3.623	3.332	3.080	2.516	2.214	2.132	1.713	0.750
50	....	0.970	2.714	3.176	2.825	2.880	2.563	1.810	1.925	1.310	....
55	....	0.340	2.052	2.938	2.606	2.640	2.195	....	....	....	....
60	....	....	1.600	2.685	2.325	2.600	....	....	....	....	....
65	....	....	1.000	2.430	2.270	....	....	....	....	....	....
70	....	....	0.960	2.2[illegible]0	....	....	....	....	....	....	....
70–95	....	....	....	2.100	....	....	....	....	....	....	....

TABLE IX.—*Showing the mean observed velocities reduced to the center of each division, for Niagara River, from June 10 to September 17, 1868.*

Depth.	1	2	3	4	5	6	7	8	9	10	11
1–2	1.896	2.598	3.723	3.676	4.257	4.284	3.750	3.579	3.565	2.608	2.255
5	2.682	2.194	3.156	4.089	4.272	4.197	3.965	3.820	3.616	3.736	1.973
10	2.326	2.336	3.344	3.428	3.830	4.195	3.802	3.695	3.358	2.975	2.151
15	2.091	2.300	3.690	3.825	3.924	3.852	3.858	3.461	3.342	2.840	2.348
20	1.825	2.360	3.256	3.717	3.820	3.684	3.677	3.509	3.434	2.619	1.983
25	1.664	2.037	3.243	3.350	3.554	3.626	3.635	3.429	3.158	2.703	1.902
30	0.600	1.945	3.275	3.643	3.552	3.346	3.616	3.297	3.108	2.725	1.482
35	....	2.441	3.174	3.725	3.442	3.652	3.257	3.082	3.156	2.243	1.050
40	....	2.308	2.958	3.401	3.326	3.436	2.994	2.758	2.929	2.518	0.800
45	....	1.937	2.751	3.386	3.340	3.143	2.660	2.492	2.283	1.773	(48) 0.650
50	....	1.624	2.660	3.291	3.006	2.905	2.563	2.055	(48.50) 2.350	(48.50) 1.610	....
55	....	0.800	2.475	3.088	3.011	2.075	(53.17) 2.210	....	....	....	....
60	....	....	1.968	3.185	2.655	(56) 1.985	....	....	....	....	....
65	....	....	1.582	2.833	(60.92) 2.590	....	....	....	....	....	....
70	....	....	(66.15) 1.450	2.530	....	....	....	....	....	....	....
70–95	....	....	....	2.480	....	....	....	....	....	....	....
Means....	1.869	2.072	2.847	3.353	3.469	3.414	3.332	3.198	3.118	2.577	1.659
Ratio to maximum	0.696	0.800	0.765	0.820	0.812	0.801	0.840	0.837	0.862	0.689	0.707

TABLE X.—*Showing the mean observed velocities reduced to the center of each division, St. Lawrence River, 1868.*

Depth.	1	2	3	4	5	6	7	8	9	10	11	12
5	(2) .4152	(2) .6177	(3) .5050	.6943	1.0264	1.4060	1.5803	1.6737	1.6340	1.6515	1.6409	1.5760
10	......	(3) .4152	.4963	.6254	1.0270	1.3662	1.5531	1.6180	1.6098	1.6299	1.5903	1.5956
15	......	......	.4370	.5354	0.8517	1.2520	1.4687	1.5886	1.6000	1.6421	1.5659	1.6030
20	......	......	......	......	0.6718	1.0346	1.3833	1.5428	1.5617	1.6355	1.5576	1.5576
25	......	......	......	......	0.5520	0.8873	1.1714	1.4747	1.5745	1.5778	1.5730	1.5513
30	......	......	......	......	......	0.8193	1.0000	1.4558	1.5517	1.5760	1.5306	1.5340
35	......	......	......	......	......	......	......	1.4276	1.5410	1.5390	1.5460	1.5224
40	......	......	......	......	......	......	......	1.2657	1.5460	1.4938	1.5124	1.4600
45	......	......	......	......	......	......	......	1.1592	1.4771	1.4624	1.4728	1.4520
50	......	......	......	......	......	......	......	1.0390	1.4235	1.4566	1.4861	1.4073
55	......	......	......	......	......	......	......	......	1.4201	1.4666	1.4422	1.3425
60	......	......	......	......	......	......	......	......	1.3367	1.4296	1.3951	1.3230
65	......	......	......	......	......	......	......	......	1.1596	1.3812	1.3653	1.2024
70	......	......	......	......	......	......	......	......	1.0200	1.2635	1.2830	1.1927
75	......	......	......	......	......	......	......	......	......	1.2062	1.2305	1.1527
80	......	......	......	......	......	......	......	......	......	1.0962	1.1823	......
Sums	0.4152	1.0329	1.4383	1.9051	4.1289	6.7654	8.1568	14.2451	20.4560	23.5979	23.3740	21.4727
Means	0.4152	0.5164	0.4795	0.6351	0.8258	1.1276	1.3595	1.4245	1.4611	1.4692	1.4609	1.4315
Ratio to max	1.0000	0.8360	0.9495	0.9147	0.8041	0.8019	0.8603	0.8511	0.8942	0.8897	0.8903	0.8930

Depth.	13	14	15	16	17	18	19	20	21	22	23
5	1.5664	1.5831	1.5330	1.5108	1.4767	1.4216	1.3470	1.2428	1.0750	0.7701	0.7657
10	1.5830	1.5675	1.5262	1.4735	1.4803	1.3772	1.3190	1.1773	1.0946	0.7985	0.6127
15	1.5656	1.5606	1.4935	1.4784	1.4703	1.3798	1.3063	1.1479	1.0870	0.8100	0.5957
20	1.5452	1.5341	1.4727	1.4492	1.4555	1.3771	1.2787	1.1149	1.0717	0.7970	......
25	1.5453	1.5392	1.4810	1.4525	1.4076	1.3695	1.2685	1.0912	0.9795	0.8110	......
30	1.5142	1.4791	1.4433	1.4031	1.3926	1.3532	1.2548	1.0534	0.9404	0.7732	......
35	1.4521	1.4756	1.4325	1.4043	1.3516	1.3324	1.2353	0.9872	0.8402	0.7463	......
40	1.4088	1.4458	1.3767	1.3501	1.3464	1.3042	1.1911	0.9460	0.7310	0.7200	......
45	1.3743	1.3971	1.3342	1.3203	1.2623	1.2512	1.1685	0.8776	0.5750	......	......
50	1.2909	1.2886	1.2530	1.2295	1.2064	1.2215	1.0987	0.8770	......	......	......
55	1.2276	1.2140	1.1363	1.1573	1.1488	1.0984	1.0694	0.8370	......	......	......
60	1.1378	1.1300	1.0370	1.0747	1.0326	1.0120	0.8694	......	......	......	......
65	1.1178	1.0000	0.8900	0.9197	0.8926	0.9000	......	......	......	......	......
70	1.0378	......	......	......	......	......	......	......	......	......	......
75	......	......	......	......	......	......	......	......	......	......	......
80	......	......	......	......	......	......	......	......	......	......	......
Sums	19.3868	18.2147	17.4094	17.2234	16.8237	16.3981	14.4067	11.3523	8.3944	6.2261	1.9741
Means	1.3848	1.4011	1.3392	1.3249	1.2941	1.2614	1.2006	1.0320	0.9327	0.7783	0.6580
Ratio to max	0.8734	0.8850	0.8736	0.8769	0.8742	0.8873	0.8913	0.8304	0.8519	0.9473	0.8883

As these divisions were 200 feet wide and five feet deep, except near the sides and bottom, they would contain 1,000 square feet, therefore, the mean velocity in each multiplied by 1,000 will give the discharge.

In the following tables are given these mean velocities for each five feet; adding up the velocity numbers for the full areas, moving the decimal point three places to the left, and adding to these the discharge of the partial areas, we have the total discharge of each division, and that for the whole river, as given at the foot of these tables.

Dividing these discharges by the area of each division and by that of the whole river we have the respective mean velocities given in the lower line.

TABLE XI.—*Showing the mean velocity and discharge for each five feet in depth in each division, and also for the whole river St. Clair, 1868.*

Depth.	1st section.		Corrected means.								Total.
	1st half.	2d half.	2.	3.	4.	5.	6.	7.	8.	9.	
2½	1.465	3.248	4.103	4.308	4.169	4.058	3.783	3.174	2.542	1.122	28942.3
7½	1.478	3.221	4.133	4.356	4.138	4.101	3.762	3.242	2.544	1.118	29072.7
12½	1.355	3.097	4.005	4.240	4.043	4.053	3.674	3.155	2.394	1.013	28195.2
17½	......	2.913	3.877	4.105	3.977	3.964	3.591	3.005	2.180	......	26267.9
22½	......	2.659	3.741	3.943	3.896	3.850	3.449	2.813	1.906	......	24927.5
27½	......	2.436	3.582	3.784	3.733	3.717	3.300	2.578	1.626	......	22718.8
32½	......	......	3.284	3.573	3.575	3.596	3.119	2.311	......	......	19458.0
37½	......	......	2.764	3.174	3.346	3.450	2.805	1.987	......	......	17332.5
42½	......	......	......	2.837	3.120	3.192	2.569	......	......	......	11203.2
47½	......	......	......	......	2.866	2.865	2.440	......	......	......	6975.4
						52 ft. 2.599	......	......	......	......	1341.5
Mean velocity	1.429	2.945	3.694	3.869	3.681	3.641	3.291	2.767	2.235	1.083	3.272
Discharge	2241.2	8553.1	29295.5	33497.3	37034.9	38015.6	31296.4	22572.9	12606.6	1321.5	216435.
Mean depth of sect's	15.68	29.04	3965	43.55	50.3	52.25	47.55	40.775	28.2	15.25	......

TABLE XII.—*Showing the mean velocity and discharge for each five feet in depth in each division, and also for the whole river Niagara, June 10th to July 17th, 1868.*

Depth.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
5	.955	1.308	1.787	4.057	4.242	4.637	4.247	4.233	3.872	3.487	1.897
10	.763	1.290	1.626	4.091	4.241	4.486	4.457	4.184	3.851	3.552	2.016
15	.652	1.313	1.739	4.165	4.291	4.258	4.557	4.151	3.878	3.456	1.955
20	.554	1.322	1.741	4.113	4.282	4.351	4.276	4.133	3.955	3.225	1.703
25	.428	1.229	1.629	3.956	4.186	4.342	4.118	4.152	3.876	3.129	1.499
30	.234	1.234	1.630	3.852	4.115	4.140	3.942	3.979	3.835	3.069	.962
35	......	1.298	1.572	3.888	4.208	3.939	3.784	3.695	3.785	2.877	.446
40	......	1.160	1.529	3.850	4.200	3.782	3.606	3.433	3.533	2.790	.022
45	......	.829	1.490	3.758	3.864	3.472	3.378	3.060	3.030	2.366	......
50	......	.531	1.358	3.518	3.629	2.953	3.009	2.838	1.540	1.000	......
55	......	.219	1.321	3.282	3.245	2.075	1.200	......	......	......	......
60	......	.052	1.160	3.137	2.031	.120	......	......	......	......	......
65	......	......	.887	2.959	.200	......	......	......	......	......	......
70	......	......	......	2.899	......	......	......	......	......	......	......
	3.292	10.878	17.970	147.502	43.172	39.279	37.450	35.884	32.448	26.740	9.692

Velocity, 3.473. Discharge, 304,307.

TABLE XIII.—*Showing the mean velocity and discharge for each five feet in depth in each division, and also for the whole river Niagara, from July 17th to September 17th, 1868.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1–5	1.030	1.038	1.786	3.877	4.133	3.727	3.697	3.790	3.277	2.498	1.434
5–10	.876	1.052	1.807	3.616	3.990	4.004	3.588	3.732	3.307	2.668	1.241
10–15	.574	1.068	1.839	3.390	3.704	3.839	3.621	3.413	3.136	2.689	1.222
15–20	.538	1.064	1.674	3.534	3.812	3.489	3.776	3.263	2.997	2.634	1.010
20–25	.410	1.040	1.612	3.339	3.626	3.370	3.686	3.248	3.033	2.708	.854
25–30	.181	.926	1.632	3.305	3.400	3.283	3.725	3.070	3.003	2.725	.478
30–35	....	1.023	1.666	3.494	3.261	3.309	3.192	2.861	2.850	2.335	.411
35–40	....	.922	1.487	3.383	3.122	3.397	2.980	2.676	2.657	1.962	.231
40–45	....	.640	1.291	3.119	3.243	3.187	2.647	2.398	2.316	1.790	.065
45–50	....	.384	1.342	3.100	3.078	2.980	2.540	2.012	2.027	1.511	....
50–55	....	.230	1.191	3.057	2.715	2.769	1.527	....	....	....	....
55–60	....	....	.913	2.611	2.466	.406	....	....	....	....	....
60–65	....	....	.650	2.557	.472	....	....	....	....	....	....
65–70	....	....	.135	2.315	....	....	....	....	....	....	....
....	....	....	....	.478	....	....	....	....	....	....	....
Means ...	3.321	8.664	17.560	41.697	37.863	34.844	31.916	28.117	26.401	21.709	6.494

Total, 258,586. Velocity, 2.971.

TABLE XIV.—*Showing the mean discharge and velocity for each five feet in depth in each division, and also for the whole river Niagara, from June 10th to September 17th, 1868.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1–5	0.950	1.195	1.719	3.883	4.264	4.240	3.857	3.700	3.690	2.672	1.427
5–10	0.876	1.132	1.625	3.758	4.051	4.196	3.883	3.757	3.487	2.855	1.248
10–15	0.707	1.159	1.758	3.727	3.877	4.023	3.830	3.578	3.350	2.907	1.293
15–20	0.528	1.165	1.736	3.771	3.872	3.768	3.767	3.485	3.388	2.730	1.115
20–25	0.410	1.180	1.624	3.533	3.687	3.655	3.656	3.469	3.296	2.661	.854
25–30	0.185	1.100	1.629	3.496	3.553	3.486	3.625	3.363	3.133	2.714	.635
30–35	....	.993	1.612	3.684	3.497	3.499	3.436	3.189	3.132	2.484	.341
35–40	....	1.096	1.533	3.563	3.384	3.544	3.125	2.920	3.042	2.380	.231
40–45	....	.849	1.428	3.393	3.333	3.289	2.827	2.615	2.616	2.145	.065
45–50	....	.589	1.353	3.338	3.173	3.024	2.611	2.278	1.621	1.183	....
50–55	....	.229	1.284	3.190	3.008	2.490	1.513	....	....	....	....
55–60	....	....	1.110	3.131	2.833	.406	....	....	....	....	....
60–65	....	....	.844	3.009	.482	....	....	....	....	....	....
65–70	....	....	.158	2.681	....	....	....	....	....	....	....
....	....	....	....	.476	....	....	....	....	....	....	....
Discharge	3.374	9.864	17.918	44.888	39.722	36.569	33.348	29.841	28.387	22.727	6.691
Mean velocity	1.880	2.218	2.919	3.427	3.541	3.537	3.397	3.235	3.171	2.550	1.903
Mean depth	21.015	48.20	66.15	70.95	60.92	56.00	3.175	50.00	48.50	48.50	27.21
Rate of minimum to maximum velocity.	0.701	0.949	0.925	0.838	0.839	0.842	0.858	0.847	0.877	0.857	0.884

Total discharge, 273,329 feet. Mean velocity, 3.119 feet.

TABLE XV.—*Showing the mean velocity and discharge for each five feet in each division, and also for the whole river St. Lawrence, 1868.*

Depth.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
2½	.183	.465	.505	.694	1.026	1.406	1.580	1.674	1.634	1.652	1.641	1.576	1.566	1.583	1.533	1.511	1.477	1.422	1.347	1.243	1.075	.770	.766
7½			.398	.658	1.027	1.386	1.567	1.646	1.622	1.641	1.616	1.586	1.575	1.575	1.530	1.492	1.479	1.399	1.333	1.210	1.085	.784	.689
12½				.834	.939	1.309	1.511	1.603	1.605	1.636	1.578	1.599	1.574	1.564	1.510	1.476	1.475	1.379	1.313	1.163	1.090	.804	1.208
17½					.762	1.143	1.426	1.566	1.581	1.639	1.562	1.580	1.555	1.547	1.483	1.464	1.463	1.379	1.293	1.131	1.079	.804	
22½					.184	.729	1.277	1.509	1.568	1.607	1.565	1.554	1.545	1.536	1.477	1.451	1.432	1.373	1.274	1.103	1.026	.804	
27½							.869	1.465	1.563	1.577	1.552	1.542	1.530	1.509	1.462	1.428	1.400	1.361	1.262	1.072	.960	.792	
32½								1.441	1.546	1.558	1.538	1.528	1.483	1.477	1.438	1.404	1.372	1.343	1.245	1.020	.890	.608	
37½								1.145	1.544	1.516	1.529	1.491	1.431	1.461	1.405	1.377	1.349	1.318	1.213	.967	.786	.235	
42½								.849	1.512	1.478	1.493	1.456	1.392	1.422	1.356	1.335	1.304	1.278	1.180	.912	.588		
47½								.990	1.450	1.460	1.479	1.430	1.333	1.343	1.294	1.274	1.235	1.236	1.134	.772			
52½									1.422	1.462	1.464	1.375	1.259	1.251	1.195	1.193	1.178	1.160	1.084	.420			
57½									1.379	1.448	1.419	1.333	1.183	1.172	1.087	1.116	1.091	1.055	1.183				
62½									.998	1.405	1.380	1.263	1.128	.959	.771	.997	1.059	.861					
67½									.872	1.322	1.324	.719	.270										
72½										1.235	1.256	.493											
77½										.806	.965												
Sums	.183	.465	.903	2.186	3.938	5.973	8.230	13.888	20.296	23.442	23.361	20.523	18.824	18.399	17.541	17.518	17.114	16.604	14.361	11.013	8.579	5.601	2.663
Areas	.440	.900	1.840	3.390	4.300	4.800	5.800	9.450	13.600	15.700	15.800	14.380	13.250	12.900	12.800	13.000	13.100	12.950	12.200	10.370	8.900	7.120	4.200

Mean volume, 272,095 cubic feet. Mean area, 211,090 square feet. Mean velocity, 1.2884 feet per second.

In the following tables are given the daily discharge, resulting velocity of wind in the direction of the river, and gauge reading for each day on which observations were taken.

The daily discharge was computed by finding the ratio between the mean discharge of each division and that of the whole river, and then multiplying the discharge found in any division by this ratio.

The numbers of the divisions from which the daily discharge is computed are given in column 4 of the tables.

The discharge when computed from the side divisions only is not considered accurate.

TABLE XVI.—*Showing the daily discharge, reading of water gauge, and direction of wind in the St. Clair River, 1868.*

Date.	Gauge—feet.	Wind—miles per hour.	Division.	Discharge—cubic feet per second.	Mean velocity—feet per second.
June 27	5.87	D. 1.86	1, 3	216,224	3.269
29	5.78	U. 7.17	4, 5	217,500	3.289
30	5.82	U. 5.37	6. 7	221,360	3.347
July 1	5.81	U. 5.89	7	214,154	3.238
2	5.77	U. 5.19	7, 8	205,600	3,109
7	5.89	D. 2.67	2, 3, 5, 6, 7, 8	218,466	3.303
8	5.85	D. 10.11	1, 2	219,819	3.323
9	5.85	D. 9.43	2, 3	229,097	3.464
10	5.84	D. 2.43	3	220,848	3.339
16	5.86	D. 7.44	4	223,409	3.378
18	5.85	U. 1.45	4	213,855	3.233
20	5.83	U. 1.70	5	220,134	3.327
21	5.84	D. 3.60	6	222,743	3.368
22	5.84	D. 6.99	6, 7	224,464	3.394
24	5.88	D. 10.79	6, 8	236,635	3.578
25	5.88	D. 10.79	1, 2	215,586	3.259
27	5.80	0.00	2, 3	217,167	3.273
28	5.80	D. 7.15	3, 4	216,229	3.269
29	5.75	U. 1.89	1, 3, 4, 5, 6, 7, 8	212,898	3.219
30	5.76	U. 3.57	5	212,493	3.213
Aug. 5	5.82	U. 2.53	7	232,231	3.511
6	5.76	U. 7.71	5	216,396	3.272
7	5.69	U. 12.54	6	200,763	3.035
Aug. 10	5.75	D. 0.07	2, 3, 5, 6	218,792	3.307
11	5.76	D. 7.92	7, 8	219,075	3.311
12	5.83	D. 10.32	2, 3, 5, 6	216,420	3.272
13	5.78	D. 0.94	1, 2, 3	215,723	3.262
14	5.76	U. 0.41	3, 4, 5, 7, 8	209,819	3.172
15	5.67	U. 3.50	5, 6	213,698	3.231
17	5.70	U. 5.56	6, 7	223,457	3.379
21	5.72	D. 11.94	1	221,628	3.351
22	5.71	D. 2.73	3, 7	211,516	3.198
24	5.68	U. 3.46	2, 4, 5, 6, 7	210,243	3.179
25	5.62	U. 5.18	1, 2	213,607	3.230
26	5.68	D. 5.04	3	222,362	3.360
Sept. 1	5.66	D. 4.98	2	219,994	3.324
2	5.59	U. 4.03	7, 8	194,020	2.933
4	5.61	U. 0.68	5	221,380	3.347
9	5.65	D. 6.83	1	198,352	2.999
10	5.55	U. 6.15	2, 6	206,388	3.120
11	5.65	D. 8.41	5	224,328	3.394
12	5.53	U. 5.45	6, 8	216,851	3.279
14	5.58	U. 3.70	2, 4	204,226	3.0[illegible]
17	5.66	D. 2.36	2, 5	206,493	3.122
Mean..	5.75	....	....	216,192	3.270

TABLE XVII.—*Showing the daily discharge, readings of water gauge, and direction of wind in the Niagara River*, 1868.

Date.		Youngstown.		Buffalo.		Division.	Discharge, cubic feet per sec'nd.	Mean velocity—feet per second.
		Gauge, feet.	Wind, miles per hour.	Gauge, feet.	Wind, miles per hour.			
June	12	2.06	....	1.72	W. S. W 4	11	314,825	3.592
	13	1.99	....	1.81	S. W 2	1, 2	244,010	2.784
	20	1.97	U........ 4.0	1.94	W 4	2	318,316	3.629
	22	2.02	D........ 3.5	1.52	N. W 4	2	259,686	2.963
	23	1.96	D........ 8.0	1.56	W 3.5	10	332,502	3.792
	24	1.95	U........ 10.4	1.58	S. W 2	9	304,220	3.471
	25	1.94	U........ 6.0	1.76	N. E 2.8	7	286,948	3.273
	26	1.96	U........ 4.5	1.63	W. S. W 2.6	7	293,223	3.345
	27	2.02	D........ 3.3	1.49	S. W 10	6	287,572	3.281
	29	1.90	D........ 3.9	1.73	S. W 2	6	281,012	3.206
	30	1.96	D........ 7.9	1.73	S. W 5.0	10	306,877	3.501
July	1	1.93	D........ 4.5	1.68	W. S. W 4.0	10	301,515	3.439
	2	1.90	D........ 3.8	1.74	W. S. W 2.0	10	297,497	3.394
	3	1.91	D........ 5.3	1.71	W. S. W 4.0	9	299,992	3.423
	6	1.95	U........ 4.0	1.78	W. S. W 2.0	9	311,866	3.510
	7	1.89	U........ 7.8	1.51	W. S. W 10.0	8	300,148	3.425
	8	1.97	U........ 8.5	1.63	W. S. W 3.0	8	311,490	3.554
	9	1.93	U........ 10.5	1.81	N 2.0	8	297,753	3.386
	10	1.97	U........ 8.5	1.81	W 2.0	5	294,755	3.362
	11	1.98	U........ 4.7	1.72	W 2.0	5	287,799	3.283
	13	2.00	U........ 3.2	1.78	S. W 2	5	297,960	3.399
	14	2.00	D........ 2.3	1.78	W. S. W 7.0	3	261,284	2.981
	15	2.00	U........ 5.0	1.63	W. S. W 4.0	4	277,134	3.161
	16	2.06	U........ 3.0	2.01	N. E 2.5	1, 2	248,116	2.830
	17	2.06	U........ 2.7	1.99	N. E 2.0	1, 8, 9, 10	279,778	3.191
	22	2.10	....	2.02	S. E. N 2	1, 3, 4, 5, 6, 7, 8, 10, 11	265,378	3.025
	23	2.21	....	2.16	N. E 2.5	7, 6, 8, 10	278,582	3.179
	24	2.13	D........ 4.3	1.93	S. W 2	2, 5	244,422	2.788
	25	2.16	.... 0......	2.13	N. E 10.0	5	300,147	3.425
	28	2.19	....	2.06	S. W 4	2, 3, 5, 7, 8, 9, 10	295,351	3.367
	29	2.22	....	2.04	W. S. W 4	4	269,476	3.074
August	3	2.22	....	2.23	S. S. E .... 2 N. W .... 4 N. E 2	2, 4, 5, 7, 8, 9, 10	271,554	3.097
	4	2.28	....	2.34	N. E 2.5	7	264,912	3.022
	5	2.33	U........ 5.8	2.06	N. E 2.0	5	267,164	3.048
	6	2.28	....	2.28	S 2.0	2, 5, 7, 9, 10	253,723	2.894
	7	2.28	....	2.08	E .... 2.0 W. S. S 4	6, 4, 8, 9	253,723	2.894
	8	2.34	D....... 19.2	1.68	W. S. S 11.0	6	257,280	2.935
	13	2.45	....	1.76	W 5.0	11	250,433	2.857
	14	2.43	D........ 7.5	1.93	W 3.0	10	234,887	2.692
	15	2.47	D....... 11.3	1.78	S. W .... 12.0 W. S. W .... 35.0 N. W 25.0	10	263,753	3.009
	18	2.46	D....... 18.5	2.29	S. W 4.0	9	239,815	2.736
	19	2.48	D....... 10.8	1.98	W. S. W 4.0	10	246,490	2.812
	20	2.47	U........ 6.4	2.06	W. S. W 2.5	10	232,242	2.647
	21	2.45	U........ 6.0	2.36	N. E 2.5	10, 11	232,242	2.647
	22	2.48	U........ 3.8	2.29	N. E 2.0	5, 9, 11	232,152	2.646
	24	2.49	.... 0......	2.43	E .... 2.0 W. S. W 2.0	3, 5, 7, 8, 10	242,764	2.770
	25	2.50	U........ 3.1	2.36	S. W 3.0	2, 5, 9, 11	246,905	2.817
	26	2.40	.... 0......	2.31	S. W 3.0	2, 4, 6, 8, 9	246,905	2.817
	27	2.53	U........ 9.1	2.73	N. E 4.0	2, 9, 11	247,022	2.819
	28	2.60	D....... 15.1	2.03	W. S. W 2.0	4, 6, 7, 10	247,022	2.819
	31	2.55	Change.......	2.19	E. N. E .... 2.0 W. S. W 6.5	6, 7	235,195	2.682
Sept.	1	2.55	....	2.09	N. W. W 3.0	9	254,036	2.898
	2	2.51	U........ 9.0	2.41	E .... 2.0 S .... 2.0 N. E 4.0	9	253,706	2.894
	3	2.53	D........ 9.8	0.43	E. N. E .... 2.0 E. by S .... 2.0 S. E 4.0	8	242,831	2.772
	4	2.58	D........ 6.7	2.19	S .... 4.0 S. S. W .... 12.0 N. W 4.0	8	242,973	2.772
	5	2.60	West.......	2.09	S. E .... 2.0 W. S. W .... 2.0 N. E 2.0	7	244,330	2.787
	7	2.50	.... 0......	2.31	N 2.0	2	255,707	2.911
	8	2.52	D........ 9.1	2.52	S 2.0	11	(?) 211,337	2.416
	9	2.55	....	2.23	S. S. W .... 1.2 E 2.0	9, 10	(?) 300,671	(?) 2.430

TABLE XVII.—*Showing the daily discharge, readings of water gauge, &c.*—Continued.

Date.	Youngstown.		Buffalo.		Division.	Discharge, cubic feet per sec'nd.	Mean velocity—feet per second.
	Guage, feet.	Wind, miles per hour.	Gauge, feet.	Wind, miles per hour.			
10	2.48	U........ 2.4	2.51	S.................. 2.0 N.W............... 2.0 S. E............... 2.0	10	200,621	2.314
11	2.50	D........ 3.7	2.46	S.................. 2.0 S. W.............. 2.0 E. N. E........... 2.0	5	199,019	2.270
12	2.53	....	2.38	S. S. E........... 2.0 S. W.............. 4.0 N. E.............. 2.0	5	239,083	2.727
14	2.54	U........ 1.1	2.79	E.................. 2.5	3	235,865	2.619
15	2.58	D....... 12.5	2.09	S. W.............. 4.0	4	266,824	3.054
17	2.64	D........ 8.8	2.19	W. by N........... 4	5	208,781	2.381

TABLE XVIII.—*Showing the daily discharge, reading of water gauge, and direction of wind in the St. Lawrence River*, 1868.

Date.	Gauge—feet.	Wind—miles per hour.	Ratio.	Discharge—cubic feet per second.	Mean velocity—feet per second.	No. of obs.	Date.	Gauge—feet.	Wind—miles per hour.	Ratio.	Discharge—cubic feet per second.	Mean velocity—feet per second.	No. of obs.
June 15	3.23	D., 8.	0.938	256,301	1.214	5	July 28	2.99	D.,10.0	1.023	278,028	1.323	10
16	3.24	Calm.	0.9812	268,186	1.223	5	29	2.92	Calm.	1.007	273,283	1.299	2
17	3.35	D., 7.7	0.963	263,913	1.247	5	31	2.91	D., 7.7	1.000	271,267	1.270	3
18	3.27	D.,10.5	1.0446	285,530	1.352	10	Aug. 3	2.95	Calm.	1.041	282,681	1.347	6
23	3.28	D., 8.8	0.949	259,700	1.230	8	4	2.77	Up, 4.5	1,049	283,783	1.352	3
24	3.11	Up, 7.4	0.954	265,830	1.263	4	5	2.77	Up,5.00	0.942	254,713	1.213	7
25	3.22	D., 2.9	0.946	263,484	1.250	6	6	2.80	Up, 2.8	1.047	283,422	1.352	1
26	3.38	D.,10.6	1.016	278,435	1.267	9	10	2.91	D., 3.2	0.980	265,860	1.265	6
29	3.17	D., 5.9	1.019	278,007	1.314	4	13	3.07	D., 3.4	1.019	277,416	1.311	5
30	3.31	D., 9.0	0.976	267,217	1.263	5	14	3.12	D.,14.0	1.022	278,555	1.322	2
July 1	3.28	D.,11.8	0.988	268,430	1.270	4	18	2.78	D., 4.7	1.015	274,607	1.309	3
2	3.25	D.,10.7	0.987	269,811	1.280	23	20	2.71	Up, 1.0	.983	265,408	1.274	4
3	3.31	D., 8.6	0.999	273,417	1.292	9	21	2.68	Up, 2.2	0.976	263,960	1.263	3
7	3.12	D., 1.4	1.023	274,307	1.303	2	22	2.76	D., 0.5	0.972	262,867	1.259	4
8	3.17	Up, 4.9	0.978	266,917	1.265	4	24	2.80	D.,12.0	.948	256,516	1.226	3
9	3.12	Up, 2.8	1.067	290.700	1.378	5	25	2.74	D., 5.0	1.022	276,108	1.325	3
10	3.20	D., 1.6	1.110	300,207	1.470	7	26	2.74	D., 8.3	0.972	262,568	1.256	4
11	3.21	D., 9.4	1.061	289,655	1.373	2	31	2.51	Calm.	.955	259,711	1.250	5
13	3.23	D.,10.0	0.993	271,303	1.298	4	Sept. 3	2.51	Up, 5.5	1.000	267,930	1.290	3
14	3.23	D., 8.1	0.987	269,673	1.278	4	4	2.62	D., 1.0	1.016	273,923	1.313	6
15	3.23	D., 4.8	1.012	276,459	1.263	6	8	2.56	Calm.	1.0360	279,007	1.339	12
20	2.87	Up, 9.2	0.900	243,716	1.160	2	10	2.63	Calm.	1.011	272,633	1.306	5
21	3.02	D., 4.6	0.9636	262,066	1.243	5	11	2.71	D., 3.7	0.987	266,647	1.276	5
22	2.91	Up, 4.3	1.039	281,905	1 344	4	12	2.56	Up, 4.9	0.936	251,847	1.208	5
23	2.80	Up, 1.9	1.051	284.502	1.361	2	14	2.56	Up, 1.3	0.985	263,153	1.272	21
24	3.04	D., 3.1	1.025	278,879	1.322	3							
25	2.88	D., 2.0	0.979	265,370	1.265	2	Means..	2.97					
27	2.96	D., 4.5	0.990	268,891	1.283	22							

Mean computed discharge, 271,673 cubic feet per second.
Mean velocity, 1.2875 feet per section.
Mean area, 211,000 square feet.

It will be noticed that the force and direction of the wind have a marked effect upon the amount of discharge, and that, except in the Niagara, there is not much change from any other cause, the decrease due to the slight fall in the general level of the river being marked by the wind effect.

The effect of the wind on the discharge, form of curve, &c., has been left for another year, when more observations will be available.

The difference between the mean of the daily discharge from these

tables and that obtained directly from the observations is very small, as will be seen by a comparison of the tables.

The change in the velocity and discharge at Niagara for the season is, however, very marked, and there are daily changes, which do not appear to be due to the wind at the place of observation.

It will be noticed that there are two tables of velocities at this point, one for the first month, and the other for the remainder of the season. These were thus divided, as it was found that during the first period there was but little variation, while during the latter the velocity and discharge rapidly decreased.

In the table of daily discharge are two columns, giving the wind and gauge reading at Buffalo. It will be noticed that the wind at Buffalo appears to have more effect upon the discharge than that recorded at the place of observation, and that the decrease in the discharge follows the fall of the Buffalo guage.

The explanation of this seems to be, that between these two points are the falls of the Niagara, where the whole body of water pours over in a thin sheet, as over a weir, and that a small difference in the depth there would make a large difference in the level below. In fact, Captain Robinson, an old resident of Niagara village, states as the result of his observation that one inch difference of depth on the crest of the fall will make a difference of a foot in the level below.

This seems to be corroborated by the fact that in the winter of 1866–7, when, on account of the water being blown back from the mouth of the river at Buffalo by a strong northeast wind, there was a fall in the level at the ferry dock below the falls of twenty-feet, the difference of depth on the crest of the falls could have been only a small proportion of this, for, except at the apex of the Horseshoe, the depth of water on the crest cannot exceed three or four feet; and though at that time the difference in the amount of water passing the falls was quite perceptible, the crest was not uncovered in any part.

It is very unfortunate that accurate measurements were not taken at that time, as such a large difference rarely occurs.

Between the falls and Lewiston, the points to which steamers can ascend, the river is quite narrow, and therefore very rapid, and the great change of level at the foot of the falls is very much decreased; and at Youngstown, five miles below, where the observations were taken, almost the only effect is seen in the change of velocity, and therefore of discharge, as the river almost immediately widens into the lake, and very little difference of level is perceptible.

Thus we must look to the change of level on the crest of the falls for the difference in the daily discharge.

It will be seen, that when the wind is southwest at Buffalo, thus heaping up the water at the mouth of the river, the discharge is proportionally increased, and vice versa.

Again, the fall of six inches in the Buffalo gauge makes a proportionate decrease on the crest of the falls, thus notably decreasing the discharge.

Besides this decrease, arising from the fall of water at Buffalo, there is, also, during cold weather, a formation of ice above the falls, which has a tendency to check the flow of water.

During the breaking up in the spring, when large quantities of ice are forced into the river from the lake, the water in Lake Erie is rapidly rising, while in the lower part of the river, as shown by the gauge at Fort Niagara, it often remains at a low stage till the latter part of April or May, when it suddenly rises a foot or more in a few days. Therefore we see that though the summer discharge is greater than that at Ogdens-

burg, it probably is decreased enough in winter to make the mean for the year sufficiently smaller to allow for the inflow from the water-shed of Lake Ontario.

This also accounts for the slight difference noticed in the last report between the outflow of the Niagara and St. Clair Rivers; for the observations at the former place were taken in August and September, when the discharge had only begun to decrease, and, as is seen in the more extended observations the past year, had become about equal to that of St. Clair.

A few observations in winter would be very interesting if it were
We cannot, therefore, at present directly compare the outflow of the
possible to take them, but the running ice would make it very difficult.
Niagara as observed with that of the other rivers.

In the following table are given the outflow of the several rivers as found by floats in 1867, corrected for difference of level of water and by meter in 1868.

TABLE XIX.—*Showing the discharge per second in the different rivers for 1867 and 1868.*

Stations.		Discharge in cubic feet per second.	
		1867.	1868.
Ste. Marie River		89, 855	
St. Clair River		231, 070	216, 435
Niagara River	1		304, 307
	2	240, 192	258, 586
St. Lawrence River		323, 435	272, 075

No observations were taken the past year in the Sault River, as it was thought that the float observations could be corrected, so as to compare its outflow with that of the other rivers; but, as before mentioned, the comparisons between the meter and floats are not sufficiently extended to deduce the law of variation. For Niagara the outflow for the first and latter part of the season are given, the latter only comparable with that of 1867, being taken during the same months.

The outflow of 1867, for the St. Clair and St. Lawrence, will be seen to be about ten per cent. too large; this again proves the correctness of the assumption that the floats give too great a velocity.

In Generals Humphreys and Abbot's report on the outflow of the Mississippi, they give the following formula for the computation of the discharge when the mid-depth velocities are known.

$$Vm = V\tfrac{1}{2}\,D - \tfrac{1}{12}\,Vbv.$$

V = mean velocity of whole river, in which
Vm = mean velocity in each division.
$V\frac{1}{2}\,D$ = mid depth velocity.
D = depth of river.

$$b = \frac{1.69}{(D-15)^{\frac{1}{2}}}.$$

a = area of each division.
A = area of cross section of river.

The form of the vertical curve being considered a parabola, the coefficient b was found equal to 0.1856, but in the following tables its value will be found for each depth and is always larger than that amount.

TABLE XX.—*Showing the mean velocity as computed by General Humphreys and Abbot's mid-depth formula, St. Clair*, 1868.

Section.	D.	V. ½ D.	b.	a.	V. ½ D.×a.	1-12 V. b.	1-12V.b.×a.
1 1	15 88	1.420	0.4077	1,568	2,226.5	.054	84.67
2 2	29 04	3.050	0.3058	2,904	8,857.2	.046	133.58
2	39 65	3.820	0.2636	7,930	30,355.5	.043	340.99
3	43 56	3.975	0.2506	8,710	34,622.3	.042	405.82
4	50 03	3.800	0.2348	10,060	38,228.0	.040	402.40
5	52 26	3.750	0.2305	10,450	38,383.8	.040	418.00
6	47 55	3.417	0.2409	9,510	32,495.7	.041	389.91
7	40 775	2.880	0.2599	8,155	23,486.4	.043	350.67
8	28 2	2.316	0.3155	5,640	13,062.3	.047	265.08
9	15 26	1.118	0.4129	1,220	1,364.0	.054	65.00
				66,147	223,081.7	....	2,856.12

TABLE XXI.—*Showing the mean velocity as computed by Generals Humphreys and Abbot's mid-depth formula, Niagara*, 1868.

Section.	Dep'h	V. ½ D.	b.	a.	V. 1-12 D.×a.	1-12 V. b.	1-12 V. b.×a.
1	21.00	2.32	0.7190	1,940	4,500	0.071	137.770
2	48.20	2.23	0.4760	4,449	9,921	0.057	253.593
3	66.15	3.17	0.2150	6,106	19,356	0.037	225.922
4	70.95	3.56	0.1980	13,097	46,625	0.036	471.492
5	60.92	3.59	0.2140	11,246	40,373	0.038	427.348
6	56.00	3.70	0.2230	10,338	38,350	0.030	403.182
7	53.17	3.55	0.2290	9,816	34,846	0.040	392.640
8	50.00	3.44	0.2350	9,230	31,751	0.040	369.200
9	48.50	3.30	0.2390	8,953	29,545	0.041	367.073
10	48.50	2.76	0.2390	8,953	24,710	0.041	367.073
11	27.20	2.06	0.3160	3,516	7,242	0.047	165.252
				87,644	287,219	....	3,580.545

TABLE XXII.—*Showing the mean velocity as computed by Generals Humphreys and Abbot's mid-depth formula, St. Lawrence, 1868.*

Section.	D. ft.	V. ½ D.	b.	a, sq. ft.	V. ½ D × a.	$\frac{1}{12}$ V. b.	$\frac{1}{12}$ V. b × a.
1	2.50	0.4000	0.8450	440	176.0	0.0767	33.75
2	4.50	0.4500	0.6900	900	405.0	0.0692	62.28
3	9.20	0.5000	0.5152	1,840	920.0	0.0598	110.03
4	17.00	0.6350	0.3930	3,390	2153.6	0.0522	177.48
5	21.75	0.9800	0.3506	4,300	4214.0	0.0492	214.02
6	24.50	1.3080	0.3274	4,800	6278.4	0.0475	232.75
7	29.40	1.4700	0.3040	5,800	8526.0	0.0460	270.48
8	46.50	1.5020	0.2419	9,450	14193.9	0.0410	381.30
9	67.00	1.5400	0.2041	13,600	20948.0	0.0375	502.50
10	78.60	1.5220	0.1889	15,700	23895.4	0.0362	569.06
11	78.50	1.5200	0.1890	15,700	23864.0	0.0362	567.34
12	72.00	1.5020	0.1974	14,380	21598.8	0.0370	532.80
13	66.00	1.4800	0.2055	13,250	19610.0	0.0377	497.64
14	64.50	1.4800	0.2078	12,900	19072.0	0.0380	500.20
15	64.00	1.4400	0.2088	12,800	18423.0	0.0381	487.65
16	65.00	1.4050	0.2070	13,000	18265.0	0.0379	492.70
17	65.50	1.3800	0.2063	13,100	18078.0	0.0378	495.15
18	64.75	1.3450	0.2074	12,950	17417.7	0.0379	490.80
19	61.00	1.2300	0.2137	12,200	15006.0	0.0385	468.60
20	52.00	1.0750	0.2313	10,370	11147.8	0.0401	402.60
21	45.00	1.0250	0.2478	8,900	9123.5	0.0415	373.50
22	36.00	0.8050	0.2756	7,120	5731.6	0.0438	315.36
23	14.04	0.7200	0.4290	4,200	3024.0	0.0546	223.86
Sum				211,090	282080.7	1.0344	8391.91

Adding together the products of the values of Vm for each division into their respective areas, and parting the sum equal to the mean velocity of the river, multiplied with the total area, we have the following equations, containing V and V½, from which the value of V can be reduced.

St. Clair ....66147 V + 2856 . 1 V½=223081.7
Niagara ....87644 V + 3580 . 0 V½=287219.0
St. Lawrence ....21090 V + 8391 . 9 V½=282080.7

From this, the outflow is obtained by multiplying these velocities by the total areas. This is given below for each river, together with the outflow as obtained directly. It will be seen that the difference is comparatively small.

TABLE XXIII.—*Showing the measured mean velocity and discharge, and the mean velocity and discharge as computed by Generals Humphreys dnd Abbot's mid-depth formula, and by the formula containing the velocity at six-tenths the depth.*

Station.	Mean velocity.			Discharge.		
	Measured.	Computed from—		Measured.	Computed from—	
		Mid depth.	Six-tenths depth.		Mid depth.	Six-tenths depth.
St. Clair	3.272	3.994	3.262	216,435	217,880	215,770
Niagara	3.119	3.203	3.150	273,329	280,757	276,079
St. Lawrence	1.288	1.291	1.301	272,095	272,398	274,720

I have not attempted the computation of the outflow by means of the general formula given by Generals Humphreys and Abbot, and as the slope or inclination of the surface of the rivers has not yet been obtained, it is impossible to compare the measured outflow with the general formula for discharge, as they all contain this quality. I expect to obtain this value the coming season.

In the following tables the ratio between the velocities in the several divisions, and the mean velocity of each river, are given.

TABLE XXIV.—*Showing the ratio of the velocity at each five feet of depth in each division to the mean velocity of the river St. Clair, 1868.*

	1st.		2	3	4	5	6	7	8	9	
	0–100	100–200									
1	0.455	0.983	1.220	1.287	1.261	1.221	1.043	0.944	0.759	....	1
5	0.440	1.002	1.288	1.346	1.287	1.226	1.169	0.996	0.794	0.343	5
10	0.463	0.967	1.238	1.317	1.242	1.250	1.130	0.986	0.761	0.340	10
15	0.365	0.926	1.210	1.274	1.229	1.228	1.113	0.943	0.703	0.278	15
20	....	0.854	1.159	1.234	1.202	1.196	1.079	0.894	0.629	....	20
25	....	0.771	1.122	1.175	1.161	1.121	1.026	0.826	0.535	....	25
30	....	29 ft. 0.715	1.062	1.138	1.120	1.111	0.988	0.750	27 ft. 0.458	....	30
35	....	....	0.945	1.046	1.064	1.084	0.918	0.663	....	....	35
40	....	....	(39) ft. 0.744	0.894	0.980	1.025	0.797	0.552	....	....	40
45	....	....	....	43 ft. 0.840	0.920	0.926	0.773	....	....	....	45
50	....	....	....	....	0.825	0.822	47 ft. 0.712	....	....	....	50
	....	....	....	....	....	53 ft. 0.764	....	....	....	....	
Depth of mean velocity from curve.	7.5	17.75	23.9	25.0	29.0	30.4	27.5	23.0	16.2	10.0	
Ratio to depth	0.48	0.61	0.60	0.57	0.57	0.58	0.58	0.54	0.56	0.66	
Mean velocity	0.437	0.900	1.129	1.183	1.125	1.113	1.006	0.846	0.683	0.331	
Ratio to depth of river.	0.72	0.58	0.60	0.54	0.58	0.55	0.57	0.58	0.56	0.70	

TABLE XXV.—*Showing the ratio of the velocity at each five feet of depth in each division to the mean velocity of the river Niagara, 1868.*

	1	2	3	4	5	6	7	8	9	10	11
1–2	0.608	0.829	1.193	1.178	1.365	1.373	1.202	1.147	1.143	0.868	0.722
5	0.860	0.703	1.012	1.311	1.323	1.346	1.271	1.224	1.159	0.877	0.632
10	0.745	0.748	1.072	1.099	1.228	1.345	1.218	1.184	1.076	0.954	0.689
15	0.670	0.737	1.183	1.226	1.258	1.235	1.237	1.109	1.071	0.910	0.753
20	0.585	0.756	1.044	1.191	1.225	1.181	1.179	1.125	1.101	0.840	0.635
25	0.533	0.653	1.030	1.074	1.139	1.162	1.165	1.098	1.012	0.866	0.609
30	(0.192)	0.620	1.040	1.168	1.139	1.072	1.159	1.057	0.996	0.873	0.443
35	....	0.782	1.017	1.194	1.103	1.171	1.044	0.988	1.011	0.719	(0.336)
40	....	0.772	0.948	1.090	1.066	1.098	0.959	0.884	0.938	0.807	(0.256)
45	....	0.621	0.882	1.085	1.038	1.008	0.852	0.795	0.732	0.568	(43) (0.208)
50	....	0.521	0.852	1.055	0.963	(0.931)	0.822	(0.658)	(48.5) (0.753)	(48.5) (0.516)	....
55	....	(0.256)	0.790	0.990	0.965	(0.665)	(53.17) (0.708)	....	....	....	....
60	....	....	0.631	1.019	(0.851)	(58) (0.636)	....	....	....	....	....
65	....	....	0.507	0.908	(60.92) (0.830)	....	....	....	....	....	....
70	....	....	(66.15) (0.465)	(0.811)	....	....	....	....	....	....	....
	....	....	....	(70.95) (0.793)	....	....	....	....	....	....	....
Depth of mean velocity from curve.	19.20	20.00	40.40	43.50	33.00	34.00	33.90	31.20	30.00	31.40	19.70
Velocity from curve.	0.91 6	6 0.41	0.61	0.61	0.54	0.61	0.63	0.62	0.62	0.64	0.72

TABLE XXVI.—*Showing the ratio of the velocity at each five feet of depth in each division to the mean velocity of the river St. Lawrence.*

Depth.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
5	(a) 0.3284	(a) 0.4885	0.3979	0.5489	0.8115	1.1104	1.2496	1.3237	1.2923	1.3057	1.2978	1.2464	1.2385	1.2519	1.2124	1.1950	1.1681	1.1246	1.0653	0.9830	0.8502	0.6089	0.6058
10	......	......	0.3925	0.4946	0.8122	1.0805	1.2283	1.2797	1.2711	1.2890	1.2577	1.2619	1.2519	1.2389	1.2070	1.1658	1.1703	1.0890	1.0413	0.9314	0.8657	0.6315	0.4846
15	......	......	0.3456	0.4629	0.6736	0.9902	1.1602	1.2564	1.2654	1.2981	1.2377	1.2678	1.2540	1.2347	1.1805	1.1690	1.1629	1.0906	1.0322	0.9079	0.8597	0.6406	0.4711
20	......	......	0.3000	0.4300	0.5313	0.8183	1.0938	1.2179	1.2275	1.2923	1.2318	1.2318	1.2219	1.2129	1.1647	1.1459	1.1511	1.0890	1.0108	0.8815	0.8476	0.6310	0.4200
25	......	......	......	......	0.4366	0.7018	0.9264	1.1663	1.2227	1.2472	1.2445	1.2227	1.2219	1.2168	1.1719	1.1481	1.1109	1.0831	1.0032	0.8623	0.7747	0.6412	......
30	......	......	......	......	......	0.6479	0.7909	1.1514	1.1681	1.2464	1.2106	1.2128	1.1976	1.1698	1.1415	1.1100	1.1009	1.0702	0.9924	0.8327	0.7438	0.6111	......
35	......	......	......	......	......	......	......	1.1290	1.1248	1.2167	1.2227	1.2040	1.1476	1.1666	1.1325	1.1104	1.0678	1.0537	0.9768	0.7808	0.6641	0.5902	......
40	......	......	......	......	......	......	......	1.0010	1.1226	1.1808	1.1958	1.1547	1.1114	1.1514	1.0884	1.0674	1.0648	1.0313	0.9427	0.7482	0.5781	0.5694	......
45	......	......	......	......	......	......	......	0.9168	1.0561	1.1563	1.1648	1.1480	1.0859	1.1049	1.0547	1.0415	0.9989	0.9894	0.9241	0.6941	0.4552	......	......
50	......	......	......	......	......	......	......	0.8304	0.9171	1.1515	1.1753	1.1109	1.0289	1.0191	0.9903	0.9724	0.9542	0.9660	0.8690	0.6940	......	......	......
55	......	......	......	......	......	......	......	......	0.8067	1.1590	1.1406	1.0618	1.9709	0.9599	0.8975	0.9153	0.9086	0.8680	0.8458	0.6619	......	......	......
60	......	......	......	......	......	......	......	......	......	1.1299	1.1034	1.0465	0.8999	0.8937	0.8208	0.8499	0.8166	0.8004	0.6876	......	......	......	......
65	......	......	......	......	......	......	......	......	......	1.0920	1.0798	0.9509	0.8830	0.7909	0.7039	0.7274	0.7059	0.7118	......	......	......	......	......
70	......	......	......	......	......	......	......	......	......	0.9994	1.0147	0.9430	0.8208	......	......	......	......	......	......	......	......	......	......
75	......	......	......	......	......	......	......	......	......	0.9539	0.9732	0.9116	......	......	......	......	......	......	......	......	......	......	......
80	......	......	......	......	......	......	......	......	......	0.8669	0.9542	......	......	......	......	......	......	......	......	......	......	......	......
Mean velocity	0.3284	0.4885	0.3590	0.4841	0.6530	0.8915	1.0749	1.1272	1.1340	1.1598	1.1553	1.1316	1.0954	1.1086	1.0590	1.0476	1.0300	0.9975	0.9493	0.8162	0.6236	0.6152	0.4479
Depth of mean velocity from curve	1.5	2.8	5.0	8.6	11.0	12.6	14.8	23.3	33.5	39.7	39.8	36.0	33.0	32.3	32.0	32.6	32.8	32.4	30.4	26.1	22.5	18.1	8.0
Ratio to depth	0.600	0.622	0.543	0.506	0.506	0.514	0.530	0.501	0.500	0.505	0.507	0.500	0.500	0.501	0.500	0.501	0.501	0.500	0.498	0.502	0.500	0.502	0.569
Ratio to depth of river	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

If curves are drawn through 1., 1.2, 1.3, 0.9, 0.8, &c., we will have the relative position of equal velocities of the current.

This method is adopted by MM. Darcy and Bazin, in their discussion of the distribution of velocities.

It will be seen that these curves follow very nearly the form of the bottom of the river, and, except in the St. Clair River, do not bend toward the center as they approach the surface. The reasons for the surface velocity of that river being too slow have been heretofore mentioned. If they were correctly taken, this form of the curve would probably disappear.

In the bottom lines of these tables are given the ratio of the mean velocity for each division to the mean velocity of the river, the depth below the surface at which the mean velocity is found, and the ratio of the latter to the whole depth.

From this it will be seen that the mean velocity will be found at about six-tenths of the depth. If, therefore, in the above mid-depth formula of Generals Humphrey and Abbot, we should introduce the velocity at six-tenths the depth instead of one-half depth, we would find that we could dispense with the correction in the second member containing experimental quantity, *b*, and yet the velocity and discharge thus computed would be much nearer the measured values.

This is done in the following tables.

TABLE XXVII.—*The mean velocity as computed from the velocities in the several divisions at six-tenths the depth, St. Clair*, 1868.

	D.	V. 0.6 D.	A.	V. 0.6 D×*a*.
½	15.68	1.390	1,568	2,179
½	29.04	2.95	2,904	8,567
2	39.65	3.70	7,930	29,341
3	43.55	3.82	8,710	33,272
4	50.30	3.645	10,060	36,669
5	52.25	3.62	10,450	37,829
6	47.55	3.25	9,510	30,908
7	40.77	2.70	8,155	22,018
8	27.20	2.24	5,640	12,633
9	15.25	1.11	1,220	1,354
V	3.262		66,147	215,770

TABLE XXVIII.—*The mean velocity as computed from the velocities in the several divisions at six-tenths the depth, Nidgara*, 1868.

		V. 0.6 *d*.	A.	V. 0.6 *d*×*a*.
1	21.	2.17	2,101.5	4,560
2	48.12	2.17	4,820	10,459
3	66.15	2.98	6,615	19,713
4	70.95	3.45	14,190	48,955
5	60.92	3.48	12,184	42,400
6	56.10	3.53	11,200	39,760
7	53.17	3.41	10,635	36,295
8	50.00	3.30	10,000	33,000
9	48.5	3.20	9,700	31,040
10	48.5	2.62	9,700	25,414
11	27.2	1.99	3,809	7,560
94,968 V=299,156. V=3.150.			94,968	299,156

TABLE XXIX.—*Showing the mean velocity as computed from the velocities in the several divisions at six-tenths the depth, St. Lawrence,* 1868.

Section.	D.	V. 0.6 D.	A.	V. 0.6 D×a.
1	2.50	0.400	440	176.0
2	4.50	0.450	900	405.0
3	9.20	0.490	1,840	901.6
4	17.00	0.625	3,390	2118.7
5	21.75	0.950	4,300	4085.0
6	24.50	1.270	4,800	6096.0
7	29.40	1.420	5,800	8196.0
8	46.50	1.460	9,450	13797.0
9	67.00	1.504	13,600	20454.4
10	78.60	1.495	15,700	23571.5
11	78.50	1.490	15,700	23542.0
12	72.00	1.460	14,380	21014.8
13	66.00	1.420	13,250	18815.0
14	64.50	1.440	12,900	18576.0
15	64.00	1.397	12,800	17881.6
16	65.00	1.360	13,000	17680.0
17	65.50	1.340	13,100	17554.0
18	64.75	1.312	12,950	16990.4
19	61.00	1.220	12,200	14884.0
20	52.00	1.030	10,370	10671.1
21	45.00	0.980	8,900	8722.0
22	36.00	0.805	7,120	5731.6
23	14.04	0.680	4,200	2856.0
Sum	....	....	211,090	274719.7

These several values of the velocity and of the discharge are given in Table XXIII, and it will be seen that they differ from the measured values by a very small amount, generally less than those found by the mid-depth formula of Generals Humphreys and Abbot.

The ratio of the mean to maximum velocity has been very differently estimated by different authors, and as it is of importance if we wish to attempt to deduce the mean from the maximum velocity, I have given in the following table the relation as found in the several divisions in the rivers under consideration.

TABLE XXX—*Showing the ratio of mean to maximum velocity in the different divisions of the several rivers,* 1868.

	1	2	3	4	5	6	7	8	9	10	11	12
St. Clair	0.91	0.85	0.85	0.86	0.86	0.84	0.83	0.82	0.93	.....	.....	.....
Niagara	0.69	0.80	0.76	0.82	0.81	0.80	0.84	0.83	0.86	0.68	0.70	.....
St. Lawrence	0.00	0.84	0.95	0.91	0.80	0.80	0.86	0.85	0.90	0.89	0.89	0.89

	13	14	15	16	17	18	19	20	21	22	23
St. Clair	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Niagara	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
St. Lawrence	0.87	0.88	0.87	0.87	0.87	0.88	0.89	0.83	0.85	0.94	0.88

Dubuat found the ratio varied from 0.71 to 0.88 in small canals. Brunning's observations, taken on the Rhine with his tachometer in 1789 and 1790, give it from 0.89 to 0.96, the depth of the river being from 5.15 feet to 14.40 feet, and the velocity from 2.19 feet to 4.86 feet per second.

Zimenes on the Arno, with a surface velocity of 3.294 feet per second and a depth of 15 feet, has a ratio of 0.92.

M. Defontaine obtained from 0.85 to 0.89 in his observations on the Rhone.

D'Aubuison remarks in this connection, that for great rivers observations give oftener above than below 0.90 for the ratio.

MM. Darcy and Bazin, in their experiments on small canals, and feeders, find this ratio to range from 0.62 to 0.85, one or two observations being a little less than the above.

But they found the ratio was greatly affected by the nature of the bottom, being less as the resistance increased. Thus we find that, in the center divisions above given, the ratio is quite regular, while on the sides, where the bottom has more influence, it is more irregular.

The above table gives about 0.87 as the mean for the deep water in the St. Lawrence, 0.82 in the Niagara, and 0.84 in the St. Clair, which is rather smaller than most of the European observations on large streams.

The locus of the maximum velocity in flowing water is generally at or near the surface, its position depending on the ratio of the depth to the width.

In MM. Darcy's and Bazin's experiments for the determination of the distribution of velocities, they give a long series of experiments in canals of different shapes, the bottom being of plank or covered with gravel, sand, cement, &c., and also upon some large feeders in masonry.

From these observations I have compiled the following tables, showing the distance of the maximum velocity of the center fillet below the surface, arranged according to the ratio of depth to the width.

TABLE XXXI.—*Showing the depth of the maximum velocity on the center vertical below the surface.*

1ST.—OBSERVATIONS ON EXPERIMENTAL CANALS.

[Compiled from MM. Darcy and Bazin's hydraulique.]

Series.	Form of canal.	Character of bottom.	Width, meters.	Depth, meters.	Ratio of depth to width.	Mean velocity, meters.	Depth of max. velocity in axis below surface.
							Met's.
No. 59-1	Rectangular	Plank	1.988	0.084	0.04	1.207	0.000
62-1	do	Strips 0.01 apart	1.988	0.109	0.05	0.961	0.000
59-2	do	Plank	1.994	0.134	0.07	1.573	0.000
65-1	do	Strips 0.05 apart	1.992	0.135	0.07	0.756	0.000
58-1	do	Plank	1.988	0.138	0.07	0.730	0.000
63-1	do	Strips 0.01 apart	1.988	0.144	0.07	1.454	0.000
63-2	do	do	1.988	0.158	0.08	1.336	0.000
61-1	do	do	1.988	0.160	0.08	0.643	0.000
60-1	do	Plank	1.994	0.180	0.09	2.297	0.000
59-3	do	do	1.994	0.201	0.10	2.501	0.000
65-2	do	Strips 0.05 apart	1.992	0.207	0.10	1.000	0.000
58-2	do	Plank	1.988	0.215	0.11	0.953	0.000
63-2	do	Strips 0.01 apart	1.988	0.218	0.11	1.925	0.000
61-2	do	Plank	1.988	0.244	0.12	0.854	0.000
62-2	do	Strips 0.01 apart	1.988	0.248	0.12	1.702	0.000
68-1	Trapezoidal	Plank	1.500	0.191	0.13	0.908	0.000
69-1	do	do	1.048	0.133	0.13	1.406	0.000
59-4	Rectangular	do	1.984	0.265	0.13	2.318	0.000
67-1	do	Strips 0.05 apart	0.800	0.110	0.14	1.084	0.000
63-3	do	Strips 0.01 apart	1.988	0.286	0.14	2.199	0.000
66-1	do	Strips 0.05 apart	1.994	0.288	0.14	1.464	0.000
55-1	do	Cement	1.812	0.269	0.15	2.509	0.000
65-3	do	Strips 0.05 apart	1.992	0.322	0.16	1.295	0.000
62-4	do	Strips 0.01 apart	1.988	0.320	0.16	1.979	0.000
58-3	do	Plank	1.988	0.332	0.17	1.248	0.000
61-3	do	Strips 0.01 apart	1.988	0.377	0.19	1.109	0.000
66-2	do	Strips 0.05 apart	1.994	0.380	0.19	1.675	0.000
68-2	Trapezoidal	Plank	1.580	0.300	0.19	1.188	0.000
69-2	do	do	1.148	0.221	0.20	1.771	0.000

TABLE XXXI.—Continued.

Series.	Form of canal.	Character of bottom.	Width, meters.	Depth, meters.	Ratio of depth to width.	Mean velocity, meters.	Depth of max. velocity in axis below surface.
							Met.
No. 58-4	Rectangular	Plank	1.988	0.436	0.22	1.429	0.030
65-4	do	Strips 0.05 apart	1.992	0.412	0.22	1.511	0.130
69-3	Trapezoidal	Plank	1.208	0.275	0.23	1.992	0.000
68-3	do	do	1.800	0.433	0.24	1.329	0.000
64-1	Rectangular	Strips 0.01 apart	1.988	0.487	0.24	0.856	0.157
56-1	do	Gravel	1.832	0.394	0.24	1.714	0.000
57-1	do	Small stones	1.860	0.452	0.25	1.471	0.090
61-4	do	Strips 0.01 apart	1.988	0.495	0.25	1.267	0.155
73-1	Semi-circular	Plank	1.100	0.270	0.25	0.966	0.000
71-1	do	Cement	1.000	0.268	0.27	1.052	0.000
69-4	Trapezoidal	Plank	1.281	0.342	0.27	2.156	0.000
68-4	do	do	1.984	0.540	0.27	1.497	0.190
72-1	Semi-circular	Fine sand	1.000	0.292	0.29	0.954	0.000
69-5	Trapezoidal	Plank	1.348	0.393	0.30	2.281	0.000
73-2	Semi-circular	do	1.260	0.377	0.30	1.230	0.000
74-1	do	Small stones	1.080	0.322	0.31	0.825	0.000
69-6	Trapezoidal	Plank	1.398	0.430	0.31	2.385	0.150
64-2	Rectangular	Strips 0.01 apart	1.988	0.660	0.33	0.948	0.230
71-2	Semi-circular	Cement	1.160	0.378	0.33	1.300	0.090
72-2	do	Fine sand	1.165	0.388	0.33	1.266	0.000
71-3	do	Cement	1.180	0.456	0.39	1.534	0.000
74-2	do	Gravel	1.170	0.458	0.39	1.028	0.120
73-3	do	Plank	1.300	0.554	0.41	1.450	0.110
72-3	do	Fine sand	1.190	0.488	0.41	1.392	0.000
71-4	do	Cement	1.200	0.528	0.44	1.676	0.000
72-4	do	Fine sand	1.210	0.554	0.46	1.569	0.000
74-3	do	Gravel	1.200	0.567	0.47	1.162	0.160
70-1	Triangular	Plank	0.800	0.380	0.47	1.406	0.000
71-5	Semi-circular	Cement	1.225	0.588	0.48	1.782	0.000
67-2	Rectangular	Plank	0.800	0.384	0.48	1.689	0.000
70-5	do	do	1.400	0.686	0.49	2.218	0.130
70-3	do	do	1.160	0.570	0.49	1.932	0.130
70-2	Triangular	do	0.980	0.480	0.49	1.719	0.130
70-6	do	do	1.480	0.735	0.49	2.294	0.130
71-2	Semi-circular	Cement	1.250	0.625	0.50	1.786	0.100
73-4	do	Plank	1.400	0.704	0.50	1.162	0.050
74-4	do	Small stones	1.220	0.610	0.50	1.229	0.200
70-4	Triangular	Plank	1.260	0.630	0.50	2.084	0.130
71-8	Semi-circular	Cement	1.250	0.632	0.50	1.810	0.000
71-7	do	do	1.250	0.662	0.53	1.786	0.000
72-5	do	Fine sand	1.250	0.662	0.53	1.679	0.050
67-3	Rectangular	Plank	0.800	0.486	0.61	1.860	0.156

2D.—OBSERVATIONS ON FEEDERS IN MASONRY.

Series.	Form of canal.	Character of bottom.	Width, meters.	Depth, meters.	Ratio of depth to width.	Mean velocity, meters.	Depth of max. velocity in axis below surface.
75-1	Trapezoidal	Masonry	1.201	0.150	0.13	1.824	0.000
2	do	do	1.203	0.234	0.19	2.352	0.000
3	do	do	1.204	0.291	0.24	2.560	0.000
4	do	do	1.207	0.358	0.29	2.707	0.000
76-1	Irregular trapezoid'l	do	2.750	0.464	0.16	0.266	0.000
2	do	do	3.000	0.623	0.21	0.391	0.383
3	do	do	3.200	0.746	0.23	0.461	0.453
4	do	do	3.400	0.835	0.25	0.513	0.400
77-1	do	do	1.996	0.663	0.33	0.253	0.203
2	do	do	2.060	0.853	0.42	0.413	0.500
3	do	do	2.080	0.987	0.47	0.501	0.300
4	do	do	2.100	1.135	0.54	0.638	0.650

From these we see that the maximum velocity of this fillet is at the surface, until the depth is more than two-tenths of the width, and that for greater depths it is nearer the surface the more the form of canal differs from a rectangle, that is, the more the sides deviate from a line perpendicularly to the bottom.

This is also seen to be independent of the mean velocity of the current. This is only true, however, of the center fillet, for in depths of which the ratio is less than two-tenths the width, the fillets one-sixth of the width on each side of the center fillet have their maximum velocity below the surface. This is also the most marked in the rectangular canal, for in the triangular canal to a depth of nearly one-half the width, and in the semi-circular, when not over two-thirds full, the curves of equal velocity follow very closely the form of the side. Thus it would seem that it is mainly the influence of the sides that causes the equal velocity curves to curve inward as they approach the surface, and that the resistance of the air has very little effect.

M. Darcy also found that the discharge from an open rectangular canal of a certain size and slope, in a calm time, was just one-half that of a tube of the same width and double height, with the same slope. Thus showing that though, as in that case, the canal was deep enough to cause the equal velocity curves to bend inward near the surface, and the maximum velocity of the center fillet to be more than one-third the depth below the surface, yet the friction on the air had no effect on the discharge.

Now as the rivers we are considering have a depth of only from two to three hundredth of their width, then if the results of the observations on small canals can be extended to large rivers, the maximum velocity should be always at the surface.

The observations of the past year show that it is certainly not below five feet from the surface, but, as before mentioned, the observations above that depth are not reliable, and, therefore, the examination of this question will have to be deferred till next year.

European observations on large streams have also generally found the maximum velocity at the surface in calm weather.

Hennocque found the maximum velocity of the Rhine to be one-fifth of the depth below the surface in calm weather, but Brunning's and Defontaine's experiments on the same river place it at the surface.

In the canal du Rhone du Rhine, it was one-third to one-fifth below the surface, except for about three feet from the middle, where it was at the surface.

This canal was of a trapezoidal form, forty-five feet wide and about twelve feet deep, thus having a ratio of 0.27, and thus conforming to the Darcy and Bazin observations.

The only exceptions to this rule I have met with, are the observations made by General Humphreys and Abbot on the Mississippi. They find the general law to be, that the maximum velocity is about one-third of the depth below the surface.

They also give a few observations on a small rectangular canal in masonry, a feeder of the Chesapeake and Ohio Canal. The width was seventeen feet and the depth 7.1 feet, making the ratio of depth to width 0.42. This, according to the observations of M. Bazin, given in the preceding tables, would make the maximum velocity of the center fillet from one-fourth to one-third the depth below the surface. It was found to be at about one-third the depth. These observations were very carefully made, and were probably as accurate a determination of the velocity as could be obtained by means of floats.

D'Aubuison says that the bottom velocity is nearly always greater than one-half that of the surface.

The bottom velocities obtained from the vertical curves and given in tables are always greater than one-half the maximum velocities, but I

think they are taken too large. Dubuat gives the velocities at which different substances will be transported by water as follows:

White clay, at 0.2458 foot per second.

Gravel, size of bean, at 1.0500 foot per second.

Fine sand, at 0.5450 foot per second.

Pebbles, inch in diameter, at 2.1315 feet per second.

Gravel, size of pea, at 0.6234 per second.

Flint stones, size of hen's eggs, at 3.2809 feet per second.

In the St. Clair bottom, velocities are given in the tables as high as 2.7 feet per second. This would be more than sufficient to carry forward large pebbles and nearly enough to transport small stones.

Now we know that the deposits in the shoals and on the delta consist mainly of fine sand and clay, and also that the depth of the river remains nearly constant; therefore, the velocity at the bottom probably does not equal two feet per second.

But this will be more particularly studied the coming season.

The form of the vertical and horizontal curves has never been agreed upon by the hydraulic engineers who have practically studied the subject.

Woltmann, from Brunning's observations on the branches of the Rhine, and some others, concluded that the vertical curve was a reversed parabola, with its axis at the bottom.

Funk, in observations on the Wesser, assumed it to be logarithmic; that is, while the depths increase in arithmetical progression, the velocities diminish in a geometrical progression.

Racourt, after a series of observations made by him on the Neva, thought it might be represented by an ellipse, whose vertex is a little below the bottom of the river and whose minor axis is a little below the surface.

Defontaine, from observations on the Rhine with a Woltmann's meter, finds that two right lines, one with more inclination than the other and having their intersection at about three-fourths the depth, approach the nearest to his results.

Eyhlerein thought that by an inclined right line the law of decrease was best shown. Generals Humphreys and Abbot found the form which agreed best with their observations was a parabola, with its axis about one-third the depth of the river below the surface.

In experiments on small canals, Bolieau found the curve to be a parabola with its axis at the surface, and M. Bazin a reversed parabola with its vertex at the bottom and of which parameter varied according to the nature of the bottom.

If, as it seems from the table given above, the velocity at the bottom must be quite small in order that it may not wear away the channel, then it must diminish very rapidly in the last few feet of depth, and, therefore, the curve which represents the velocities in any vertical plane must either be tangent to the bottom or cut it at a very obtuse angle.

The generally admitted theory of flowing water, that the bottom being moistened the horizontal fillet nearest the bottom is retarded by the resistance of the bed, the next by a less amount, and so on until equilibrium is reached, would seem to be confirmed by the rapid diminution of velocity near the bottom.

There are several reasons why the bottom velocity, as assumed by different engineers, should be too great.

This has been shown heretofore as regards the use of floats.

In a meter one similar cause of error may creep in if great care is not taken; that is, the curve formed by the line by which the meter is sus

pended, and, therefore, the velocity in a plane much above the bottom is taken for that near the bottom; and second, the determination of the coefficient which is assumed as a constant gives too large a velocity for a small number of revolutions per second.

It seems, therefore, it is impossible to represent the lower portion of the velocities by any simple line; it must be by a curve whose vertex is at or near the bottom, and, therefore, will increase rapidly, and not by a straight line, nor by what is nearly the same thing, by that part of a parabola at some distance from the focus.

There are two difficulties in attempting to find the curve representing the velocities in any plane;

1. The interpolations for missing observations.

If there are but few observations missing in a large number taken, then it will make but little difference whether we interpolate or not, for it will make but a slight variation in the mean, but if the missing observations are numerous, then (as they must be interpolated either in a straight line drawn between the known points, or on a curve) the mean will approximate more or less to the line or curve by which the interpolations were made.

2. In comparing velocities in planes where the depth is different, if we compare them directly, then we will have entirely different portions of the curve opposite, and if we divide them into equal parts, the velocities will have to be interpolated in the manner just mentioned, and the mean will be of the same form as the line or curve of interpolation.

But as the depth of the river varies so much, we would generally have too few results at the same depths to eliminate the errors of observation.

In order to avoid these errors as much as possible, tables B have been computed from the observations given in tables A.

The velocities are grouped for every three feet in depth of the river in the central divisions, where the retarding influence of the shore is the least.

The only interpolation is near the bottom, when the last observed velocity was not taken on an even five feet of depth.

These are reduced to the nearest five feet by a direct proportion.

The means of these groups will, therefore, be as near as possible to the true velocity at the several depths.

The largest number of observations at any depth will be seen to be at sixty-five feet at Ogdensburg, and forty-five feet at St. Clair. These two series will be taken for comparison with different curves.

In the first columns of the following tables we have these mean velocities and in the remaining column the several curves proposed by different engineers as mentioned above.

TABLE XXXII.—*Comparison of the observed sub-surface velocity, at nearly the same depth of river, with the different vertical curves assumed by hydraulic engineers.*

ST. CLAIR RIVER, DEPTH FROM 43 TO 45 FEET.

Depth of observation below surface.	Observed velocities—feet per second.	Parabola, Humphreys and Abbot.	Difference from observation.	Reversed parabola.	Difference from observation.	Logarithmic curve.	Difference from observation.	Straight lines intersecting at 0.6 of depth.	Difference from observation.	Ellipse.	Difference from observation.
0	3.850	3.566	−0.284	4.090	+0.240	4.200	+0.350	4.100	+0.250	4.063	+0.213
5	4.019	3.566	−0.453	3.997	−0.012	3.990	−0.029	4.004	−0.015	4.017	−0.0[illegible]2
10	3.941	3.549	−0.392	3.875	−0.066	3.791	−0.150	3.908	−0.033	3.949	+0.00[illegible]
15	3.833	3.516	−0.317	3.743	−0.090	3.601	−0.232	3.812	−0.021	3.862	+0.029
20	3.696	3.466	−0.230	3.600	−0.096	3.421	−0.275	3.715	+0.019	3.744	+0.04[illegible]
25	3.566	3.398	−0.168	3.442	−0.124	3.251	−0.315	3.619	+0.053	3.597	+0.031
30	3.401	3.314	−0.087	3.216	−0.185	3.088	−0.313	3.413	+0.012	3.410	+0.009
35	3.147	3.213	+0.066	3.049	−0.098	2.934	−0.213	3.160	+0.013	3.165	+0.01[illegible]
40	2.629	3.096	+0.467	2.771	+0.142	2.787	+0.158	2.738	+0.109	2.817	+0.1[illegible]
44	1.900	2.961	1.061	2.100	+0.200	2.676	+0.776	2.400	+0.500	1.900	0.000
Sums.....	33.644	33.645	3.525	....	1.253	....	2.811	....	1.025	....	0.646
Means....	....	....	0.353	....	0.125	....	0.281	....	0.103	....	0.065

ST. LAWRENCE RIVER, DEPTH FROM 63 TO 65 FEET.

0	1.510	1.435	−0.075	1.526	+0.016	1.555	+0.045	1.530	+0.020	1.509	−0.001
5	1.510	1.435	−0.075	1.516	+0.006	1.510	0.000	1.512	+0.002	1.508	−0.002
10	1.480	1.429	−0.051	1.489	+0.009	1.465	−0.015	1.494	+0.014	1.490	−0.010
15	1.489	1.421	−0.068	1.467	−0.022	1.421	−0.068	1.486	−0.003	1.475	−0.014
20	1.468	1.411	−0.057	1.444	−0.024	1.378	−0.090	1.458	−0.010	1.459	−0.009
25	1.457	1.397	−0.060	1.420	−0.037	1.337	−0.120	1.440	−0.017	1.438	−0.019
30	1.420	1.380	−0.040	1.394	−0.024	1.296	−0.124	1.412	−0.008	1.414	−0.006
35	1.402	1.360	−0.042	1.366	−0.036	1.257	−0.143	1.404	+0.002	1.385	−0.017
40	1.365	1.337	−0.028	1.336	−0.029	1.220	−0.145	1.375	+0.010	1.353	−0.012
45	1.325	1.309	−0.016	1.303	−0.022	1.183	−0.142	1.301	−0.024	1.313	−0.012
50	1.268	1.279	+0.011	1.265	−0.003	1.147	−0.121	1.227	−0.041	1.264	−0.004
55	1.161	1.246	+0.085	1.220	+0.059	1.114	−0.047	1.153	−0.008	1.207	+0.046
60	1.078	1.209	+0.131	1.161	+0.083	1.080	+0.002	1.079	+0.001	1.123	+0.045
64	0.900	1.185	+0.285	1.020	+0.120	1.054	+0.154	1.020	+0.120	0.910	+0.010
Sums.....	18.833	18.833	1.024	....	0.490	....	1.216	....	0.280	....	0.2[illegible]
Means....	....	....	0.073	....	0.035	....	0.087	....	0.020	....	0.015

From these comparisons it will be seen that the curve which approaches nearest to the observed velocities is an ellipse, its major axis vertical, and its minor axis at or just above the surface. M. Racourt placed the vertex of the ellipse a little below the bottom, but I find it agrees best with my observations when at the bottom. The minor axis should, apparently, be at the surface in the slow, and a little above it in fast velocities.

The straight lines intersecting at six-tenths of the depth, suggested by M. Defontaine, would, if the bottom velocity was a little increased, be nearer the observations than the ellipse, but, as I have heretofore remarked, I think the bottom velocity ought to be rather diminished than increased beyond that I have assumed.

I hope next year to report more fully on this point, as I shall this season study especially the velocities near the bottom and the surface.

It has been long known that there was great irregularity of flow in running water, but heretofore there has been no means of ascertaining the amount or duration of these irregularities or pulsations.

M. Bazin says, (Hydrauliques, page 22 and 23:) The movement of

water in a canal is much more complicated than at first appears. If we observe the velocity of a certain point, we very soon perceive that it is changing continually.

These variations are sudden; they oscillate by quick impulses, and are accompanied by little changes of the surface level.

These continual fluctuations have been already noticed by many observers, and M. Baumgarten has observed them upon the Garrone by aid of a Woltmann's meter.

Appreciable even by such an instrument as a meter, which has to run for a certain number of seconds before giving any result, they are much more so by means of an instrument like the gauging tube of M. Darcy, which measures the velocity by quick impulses exerted during a very short time. They are also mentioned by Mr. James B. Francis in the Lowell Hydraulics Experiments, page 175. Mr. John A. Bailey, who was the engineer of the company who laid the first Cuba telegraph cable, tells me that while lying near the buoys, which were put out near the end of the shore cable, about ten miles from Key West, he has often noticed them in calm time, surging down so as to be almost submerged, and again rising so as to be half way out of water.

This would occur every two or three minutes, and when anchored between two of the small keys west of the Florida coast, during a calm night, he says, that the steamer would every few minutes drag back on the cable with such force as to make persons standing on deck almost lose their balance.

This seems to prove that these pulsations are found in the Gulf stream as well as in small canals and rivers.

I am also informed that the oil wells have similar pulsations, differing only in being regular, the time between maximums being from twenty to forty seconds in different wells.

This is best shown in the flowing wells, from which the oil will rush with great velocity for a few seconds, and then barely overflow, or, as in some wells, cease altogether.

On the other hand, I have not been able to discover any very marked difference in the flow of the artesian wells at Chicago, where the water rises fifty feet or more above the mouth of the well, though I have not yet been able to put a meter into the current.

It has also been noticed that when jets are thrown up from a pipe, communicating with a reservoir of a constant level, that the elevation reached by the jet is never uniform, but oscillates between certain limits, these oscillations not being regular, but occurring at intervals of ten or more seconds.

I have found these pulsations in every stream I have had access to, and in the following tables I give a few results. These were obtained by putting a Morse register in the circuit; every revolution of the meter causing a dot to be made on the moving paper. The mean point between each maximum and minimum was then found. The time between each of these mean points was measured by a scale, and the number of dots counted.

These pulsations for St. Clair River are given in the following tables, as time and revolutions on the maximum and minimum sides of these points.

This method of expressing the pulsations does not give the true maximum and minimum, and I could find no way of putting in figures the record shown on the register papers.

TABLE XXXIII.—*Pulsations in St. Clair River, 208 feet from base; depth of river 28 feet; wind down 11. 9 miles per hour, August 21, 1868.*

MAXIMUM.			MINIMUM.			TOTAL PULSATION.		
Number of revolutions.	Duration in seconds.	Revolutions per second.	Number of revolutions.	Duration in seconds.	Revolutions per second.	Number of revolutions.	Duration in seconds.	revolutions per second.
METER 20 FEET BELOW SURFACE.								
30	10	3.00	10	4	2.50	40	14	2.85
24	8	3.00	55	24	2.23	79	32	2.47
35	12	2.91	20	8	2.50	55	20	2.75
31	10	3.10	43	20	2.15	74	30	2.47
40	16	2.50	36	16	2.25	76	32	2.38
32	12	2.66	41	18	2.28	73	30	2.43
42	16	2.62	38	16	2.12	80	32	2.50
35	14	2.50	26	11	2.36	61	25	2.44
17	7	2.43	23	10	2.30	40	17	2.35
32	12	2.66	31	12	2.50	63	24	2.63
42	14	.30	16	6	2.66	58	20	2.90
32.7	11.9	2.75	30.8	13.2	2.33	63.5	25.1	2.53
METER 22 FEET BELOW SURFACE.								
12	5	2.40	10	5	2.00	22	10	2.20
32	11	2.91	39	21	1.89	71	33	1.15
29	12	2.40	52	19	2.74	61	31	1.97
26	11	2.36	10	5	2.00	36	16	2.25
59	25	2.36	12	6	2.00	71	31	2.29
28	12	2.33	13	7	1.86	41	19	2.16
METER 22 FEET BELOW SURFACE. 2 1.								
20	7	2.86	32	14	2.29	52	21	2.48
59	20	2.95	44	18	2.45	103	38	2.9[illegible]
33.1	12.6	2.63	25.7	13.2	1.95	50.8	22.1	2.30
METER 10 FEET BELOW SURFACE.								
26	8	3.25	42	18	2.33	68	26	2.61
17	6	2.83	15	6	2.50	32	12	2.66
11	4	2.75	37	14	2.64	48	18	2.67
27	8	3.37	38	13	2.92	65	21	3.09
28	9	3.11	35	12	2.92	63	21	3.00
40	12	3.33	69	22	3.14	109	34	3.21
46	14	2.85	54	16	3.38	100	30	3.33
44	12	3.66	31	9	3.44	75	21	3.57
36	10	3.60	38	11	3.45	74	21	3.52
67	19	3.53	54	17	3.17	121	36	3.37
46	14	3.28	46	15	3.07	92	29	3.17
42	14	3.00	48	16	3.00	90	30	3.00
35.8	10.8	3.31	42.2	14.1	3.00	78.1	24.1	3.24

TABLE XXXIV—*Pulsations in St. Clair River, 1,411 feet from base; depth of river 42 feet; wind up 0.7 miles per hour.*

MAXIMUM.			MINIMUM.			TOTAL PULSATION.		
Number of revolutions.	Duration in seconds.	Revolutions per second.	Number of revolutions.	Duration in seconds.	Revolutions per second.	Number of revolutions.	Duration in seconds.	Revolutions per second.
METER 5 FEET BELOW SURFACE.								
77	20	3.85	50	16	3.12	1.27	36	3.53
52	16	3.25	52	16	3.25	1.04	32	3.25
43	11	3.82	56	17	3.29	.99	28	3.53
79	21	3.76	53	16	3.31	1.32	37	3.57
31	9	3.44	41	13	3.15	.72	22	3.27
53	14	3.78	39	11	3.55	.92	25	3.68
41	13	3.15	31	10	3.10	.72	23	3.13
24	7	3.43	2[illegible]	8	3.50	.52	15	3.47
27	7	3.83	24	7	3.43	.50	14	3.64
31	8	3.87	42	12	3.50	.73	20	3.65
58	16	3.62	32	11	2.91	.90	27	3.33
46.9	12.9	3.6[illegible]4	42.3	12.9	3.28	87.6	25.4	3.45
METER 15 FEET BELOW SURFACE.								
60	17	3.53	68	19	3.58	128	36	3.56
81	22	3.68	83	28	2.96	164	50	3.28
99	32	3.09	68	22	3.09	167	54	3.09
78	23	3.38	79	23	3.43	157	46	3.41
58	16	3.62	43	13	3.31	101	29	3.48
46	15	3.07	42	14	3.00	88	29	3.03
51	15	3.40	44	14	3.14	95	29	3.27
67.6	20.0	3.38	61.1	19.0	3.22	128.6	39.0	33.0
METER 25 FEET BELOW SURFACE.								
122	38	3.21	61	22	2.77	1.83	60	3.05
48	14	3.43	21	7	3.00	69	21	3.29
43	14	3.07	36	13	2.77	79	27	2.93
27	8	3.38	54	20	2.70	81	28	2.89
55	17	3.23	49	17	2.88	104	34	3.06
28	9	3.12	22	8	2.75	50	17	2.94
33	11	3.00	31	11	2.82	64	22	2.91
35	13	2.69	40	15	3.33	75	28	2.60
48.9	15.5	3.15	41.3	15.1	2.73	88.1	27.1	3.25

MAXIMUM.			MINIMUM.			TOTAL PULSATION.		
Number of revolutions.	Duration in seconds.	Revolutions per second.	Number of revolutions.	Duration in seconds.	Revolutions per second.		Duration in seconds.	Revolutions per second.
METRR 35 FEET BELOW SURFACE.								
52	28	1.86	39	33	1.18	91	61	1.49
10	4	2.50	20	16	1.25	30	20	1.50
23	11	2.09	16	11	1.46	39	22	1.77
65	33	1.97	39	30	1.30	1.04	63	1.65
8	5	1.60	17	15	1.13	25	20	1.25
10	6	1.66	13	10	1.30	23	16	1.44
16	8	2.00	13	8	1.63	29	16	1.81
9	5	1.80	11	7	1.57	20	12	1.67
43	20	2.15	9	6	1.50	52	26	2.00
27	14	1.93	16	10	1.60	43	24	1.79
12	6	2.00	12	9	1.33	24	15	1.67
14	7	2.00	41	28	1.46	55	35	1.57
19	9	2.11	9	6	1.50	28	15	1.87
23.7	12.0	1.98	1.93	14.4	1.34	43.3	26.5	1.63
METER 36 FEET BELOW SURFACE.								
36	16	2.25	29	16	1.81	65	32	2.03
44	19	2.31	30	19	1.63	74	38	1.95
20	11	1.82	16	12	1.33	36	23	1.56
14	9	1.55	14	13	1.07	28	22	1.28
40	20	2.00	29	27	1.70	69	37	1.87
27	13	2.07	27	16	1.69	54	29	1.86
27	13	2.07	16	10	1.60	43	23	1.87
18	11	1.64	12	14	0.85	30	35	0.86
39	25	1.56	13	14	0.93	52	39	1.33
21	13	1.62	17	11	1.55	38	24	1.58
16	8	2.00	9	7	1.29	25	15	1.66
23	10		18	10	1.80	41	20	2.05
17	8	2.30	32	20	1.60	49	28	1.75
41	18	2.13	14	7	2.00	55	25	2.20
28	10	2.28	48	43	1.12	76	53	1.44
26	13	2.80	44	39	1.08	70	52	1.35
212	105	2.00	27	25	1.08	2.39	130	1.84
		2.02						
3.82	18.9	2.02	23.2	17.2	1.35	61.4	36.1	1.70

TABLE XXXV.—*Pulsations in St. Clair River, 487 feet from base; depth of river 45 feet; wind up 5.0 miles per hour. September 14, 1868.*

Maximum.			Minimum.			Total pulsation.		
Number of revolutions.	Duration in seconds.	Revolutions per second.	Number of revolutions.	Duration in seconds.	Revolutions per second.	Number of revolutions.	Duration in seconds.	Revolutions per second.
METER 5 FEET BELOW SURFACE.								
55	10	5.50	53	12	4.42	108	22	4.91
29	6	4.83	53	12	4.42	82	18	4.56
40	8	5.00	52	12	4.33	92	20	4.60
43	8	5.41	86	20	4.30	123	28	4.39
21	4	5.25	18	4	4.50	39	8	4.85
91	18	5.06	16	4	4.00	107	22	4.86
10	2	5.00	14	4	3.50	24	6	4.00
11	2	5.50	17	4	4.25	28	6	4.50
44.2	8.20	5.39	36.9	8.50	4.34	77.8	16.6	4.69
METER 10 FEET BELOW SURFACE.								
33	6	5.50	52	12	4.33	85	18	4.72
19	4	4.75	88	20	4.40	107	24	4.46
38	8	4.75	54	12	4.50	92	20	4.60
29	6	4.83	79	18	4.39	108	24	4.50
71	14	5.07	16	4	4.00	87	18	4.83
55	12	4.58	24	6	4.00	79	18	4.39
37	8	4.63	23	6	3.83	60	14	4.29
9	2	4.50	47	12	3.92	56	14	4.00
50	10	5.00	8	2	4.00	58	12	4.83
46	10	4.60	8	2	4.00	54	12	4.50
38.7	......	......	......	......	......	......	......	......
METER 20 FEET BELOW SURFACE.								
62	10	6.20	79	18	4.39	141	28	5.04
45	10	4.50	24	6	4.00	69	16	4.31
9	2	4.50	62	16	3.88	71	18	3.95
18	4	4.50	14	4	3.50	32	8	4.00
123	28	4.39	30	8	3.75	153	36	4.25
37	8	4.63	7	2	3.50	44	10	4.40
METER 20 FEET BELOW SURFACE—CONTINUED.								
93	20	4.65	25	6	4.17	118	26	4.54
26	6	4.50	33	9	3.66	59	15	3.93
28	5	5.60	16	4	4.00	44	9	4.89
49.8	10.5	4.74	32.2	8.1	3.98	81.2	18.4	4.42
METER 30 FEET BELOW SURFACE.								
60	14	4.28	25	7	3.57	85	20	4.05
27	7	3.88	37	16	3.70	64	17	3.76
18	4	4.50	90	22	4.09	108	26	4.15
65	14	4.64	37	10	3.70	102	24	4.25
12	3	4.00	32	10	3.20	44	13	3.38
32	7	4.57	12	3	4.00	44	10	4.40
76	17	4.47	62	17	3.65	138	34	4.06
109	24	4.54	8	2	4.00	117	26	4.50
49.9	11.2	4.49	37.9	10.1	3.75	87.7	21.4	4.09
METER 40 FEET BELOW SURFACE.								
16	4	4,00	27	8	3.38	43	12	3.58
11	3	3.66	27	9	3.00	38	12	3.16
12	3	4.00	10	3	3.33	22	6	3.66
17	5	3.40	9	3	3.00	26	8	3.25
35	8	4.38	16	5	3.20	51	13	9.92
80	20	4.45	41	11	3.73	130	31	4.19
21	4	5.25	14	4	3.50	35	8	4.38
12	3	4.00	81	26	3.12	93	29	3.42
24	6	4.00	111	32	3.16	135	38	3.55
45	11	4.09	12	4	3.00	57	15	3.80
28.2	6.7	4.21	34.0	10.3	3.30	63.0	17.2	3.66

TABLE XXXVI.—*Mean pulsations St. Clair River, August* 21, 1868, 208 *feet from base; depth of river*, 28 *feet; wind down*, 11.9 *miles per hour.*

Depth below surface.	MAXIMUM. No. of revolutions.	MAXIMUM. Duration in seconds.	MAXIMUM. Revolutions per second.	MINIMUM. No. of revolutions.	MINIMUM. Duration in seconds.	MINIMUM. Revolutions per second.	TOTAL PULSATION. No. of revolutions.	TOTAL PULSATION. Duration in seconds.	TOTAL PULSATION. Revolutions per second.	Velocity of river, feet per second.
10 feet	35.8	10.8	3.31	42.2	14.1	3.00	78.1	24.1	3.24	2.845
20 feet	32.7	11.9	2.75	30.8	13.2	2.33	63.5	25.1	2.53	2.638
22 feet	33.1	12.6	2.63	25.7	13.2	1.95	50.8	22.1	2.30	2.500

August 22, 1868, 1,411 *feet from base; depth of river*, 42 *feet; wind up*, 0.7 *miles per hour.*

Depth below surface.	MAXIMUM. No. of revolutions.	MAXIMUM. Duration in seconds.	MAXIMUM. Revolutions per second.	MINIMUM. No. of revolutions.	MINIMUM. Duration in seconds.	MINIMUM. Revolutions per second.	TOTAL PULSATION. No. of revolutions.	TOTAL PULSATION. Duration in seconds.	TOTAL PULSATION. Revolutions per second.	Velocity of river, feet per second.
5 feet	46.9	12.9	3.64	42.3	12.9	3.28	87.6	25.4	3.45	3.049
15 feet	67.6	20.0	3.38	61.1	19.0	3.22	128.6	39.0	3.30	2.963
25 feet	48.9	15.5	3.15	41.3	15.1	2.73	88.1	27.1	3.25	2.663
35 feet	23.7	12.0	1.98	19.3	14.4	1.34	43.3	26.5	1.63	1.666
36 feet	38.2	18.9	2.02	23.2	17.2	1.35	61.4	36.1	1.70	1.600

September 14, 1868, 487 *feet from base; depth of river*, 45 *feet; wind up*, 5.0 *miles per hour.*

Depth below surface.	MAXIMUM. No. of revolutions.	MAXIMUM. Duration in seconds.	MAXIMUM. Revolutions per second.	MINIMUM. No. of revolutions.	MINIMUM. Duration in seconds.	MINIMUM. Revolutions per second.	TOTAL PULSATION. No. of revolutions.	TOTAL PULSATION. Duration in seconds.	TOTAL PULSATION. Revolutions per second.	Velocity of river, feet per second.
5 feet	44.2	8.20	5.39	36.9	8.50	4.34	77.8	16.6	4.69	4.057
10 feet	38.7	8.00	4.83	39.9	9.4	4.24	78.6	17.4	4.58	4.026
20 feet	49.8	10.5	4.74	32.2	8.1	3.98	81.2	18.4	4.42	3.871
30 feet	49.9	11.2	4.49	37.9	10.1	3.75	87.7	21.4	4.09	3.498
40 feet	28.2	6.7	4.21	34.0	10.3	3.30	63.0	17.2	3.66	2.778

The above table, however, shows the duration and mean number of revolutions near the maximum and minimum.

The time occupied by a pulsation varies from a few seconds to over a minute, not appearing to be at all regular. They are greater at the bottom than at the surface, and therefore cannot be accounted for on M. Bazin's theory, hereafter noticed, "as due to the tumultuous action at the surface caused by friction on the air." I found that eddies made no difference with them, as in the canal at Odgensburg they were about the same in the stiller portions as at the grating, where the water forced through from the dam. They were also perceptible in the tail-race of a mill, where the water was quite shallow, and rushing with great velocity over a strong bed, and in the St. Lawrence where the volume of water is so great and the current slow.

Savart experimented on the form of discharge of water flowing from

an orifice in the bottom of a reservoir, and found that though the vein was of a cylindrical form between the orifice and the contracted section, yet at a small distance beyond the latter point a succession of shrinkings and swellings of the vein took place, which further became drops alternately large and small, there being between each drop a space eight or ten times its mean diameter. The form of the drops oscillated between a prolate and oblate spheroid.

Thus we see that water, when flowing freely from an orifice, under a constant head, is subject to continual variations apparently caused by the action of the air, and it may be that the motion of the water in tubes or open channels is affected in the same manner, and thus cause these pulsations. There is another cause which would perhaps account for the large pulsations, and that is the continual oscillation of the water in the lakes.

In calm summer days, without any apparent cause, the water is continually rising and falling. This can be seen on the sheets of the self-registering water gauge, or in small streams at the head of deep bays. In the latter, if the fall is not large near the lake, the current is continually changing up and down; the time of one ebb and flow being from ten to twenty minutes.

These changes of level have also been noticed in the lakes of Switzerland, and in the Caspian Sea, so that they seem to be incident to all large bodies of water.

They have been attributed to the varying atmospheric pressure, but they are more rapid than any barometic oscillation, and they are probably more due to disturbances of the crust of the earth.

Humbodlt was of the opinion that earthquakes were continually occurring in all parts of the world, and that it was only the larger ones which were noticed; and astronomical observers now find that their instruments are subject to perturbations which are only to be accounted for on some such theory.

Bazin again says, (Hydrauliques, pages 23 and 25,) "These irregular movements appear to be preferably produced in the greatest sections, but it is, above all, in the neighborhood of the surface that these variations, or, better called, perhaps, the disturbances of the velocities, are the most remarkable."

And he further says, "That the changes in the curves of equal velocities, seen in a rectangular tube, and an open canal of the same width and half the height heretofore mentioned, cannot be accounted for by the resistance of the air, but must be due to the interior movements of the fluid. For, in a tube, the symmetry and invariability of the section establishes among the molecules a kind of solidity, which contributes to make the velocity regular. In an open canal, on the contrary, the absence of pressure in the surface of the current, the want of symmetry in the section, which freely permits the augmenting or diminishing of the incessant, from which the current is not exempt, favor, without doubt, the productions of these tumultuous movements in the superior fillets."

Whether, as he seems to intimate, there are no pulsations in a closed tube, I am not able at present to say, as I have had no means of testing it, but, as will be seen from the tables, there is no increase of the pulsations near the surface, but generally they are the greatest when we approach the bottom and sides, and they seem to be about the same in the generally even-flowing river as in the small, eddying canal.

Dubuat, in the course of his experiments on the action of water on different substances placed in his experimental canal, covered the bottom

of it with a layer of sand, which moved with the water under a velocity of one foot a second.

After some time the sand presented a series of beautiful undulations or ridges 0.4 foot broad.

The grains of sand, forced on by the current, rose to the top of the ridges, and, after falling down by their own weight to the base of the next ridge, were again lifted to the summit; he found that half an hour was required for a particle to traverse a complete ridge, so that the rate of motion would be about twenty feet in twenty-four hours.

These ridges seem to be the effect of the pulsations, for the formation of the sand dunes by the wind is probably due to the fact that its force is irregular, the sand borne forward during its greater velocity being dropped when that velocity decreases; an irregularity in the surface being thus produced, which will cause greater resistance to the passage of the next sand-bearing current, and thus cause the deposition of more particles upon its surface. But more data is required before we can reason intelligently upon this subject.

In the following table is given the rain-fall on the water-shed of the lakes up to December, 1868. The table is a continuation of that given last year:

TABLE XXXVII.—*Rain-fall in the region of the great lakes.*

Lakes.	Station.	No. of years—observations.	Mean yearly rain-fall—inches.	Mean yearly rain-fall for the several lakes—inches.	Mean daily rain-fall—inches.
Lake Superior	Superior, Wis	9	25.4	28.12	0.0770
	Ontonagon, Mich	9	25.2		
	Marquette, Mich	9	28.7		
	Sault Ste. Marie, Mich	17	30.8		
Lake Michigan	Fort Howard, Wis	8	34.6	30.63	0.0839
	Appleton, Wis	3	31.8		
	Fort Winnebago, Wis	9	27.5		
	Milwaukee, Wis	22	30.3		
	Janesville, Ill	5	32.6		
	Battle Creek, Mich	3	33.5		
Lake Huron	Mackinac, Mich	12	23.7	27.94	0.0765
	Thunder Bay Island, Mich	7	33.2		
	Tawas, Mich	8	22.1		
	Fort Gratiot, Mich	11	32.6		
Lake Erie	Detroit, Mich	10	30.0	32.59	0.0892
	Monroe, Mich	9	30.7		
	Oberlin, Ohio	3	33.3		
	Cleveland, Ohio	10	38.0		
	Hudson, Ohio	9	33.6		
	Buffalo, N. Y	10	32.4		
Lake Ontario	Fort Niagara, N. Y	9	26.3	32.59	0.0892
	Toronto, Ontario, Canada	27	35.0		
	Rochester, N. Y	4	35.6		
	Penn Yann, N. Y	6	28.7		
	Charlotte, N. Y	9	29.9		
	Sackett's Harbor, N. Y	9	35.6		

TABLE XXXVIII.—*Bi-five day means of the height of the water for the several places of observation*, 1868.

The following table gives the stage of water for the season at the several stations, below the high water of 1838:

Date.	Water below the high water of 1838.				Date.	Water below the high water of 1838.			
	St. Clair.	Niagara.	St. Lawrence.	Sault Ste Marie.		St. Clair.	Niagara.	St. Lawrence.	Sault Ste Marie.
June 11 to 20	2.02	2.02	1.94	2.06	Sept. 1 to 10	2.21	2.54	2.39	1.[illegible]
16 to 25	1.96	1.99	1.97	2.06	6 to 10	2.23	2.53	2.47	1.[illegible]
21 to 30	1.93	1.96	1.49	2.08	11 to 20	2.18	....	2.50	1.[illegible]
26	1.97	1.94	1.91	2.02	16 to 25	2.18	....	2.61	1.7[illegible]
July 1 to 10	1.96	1.93	2.02	1.98	21 to 30	2.29	....	2.50	1.[illegible]
6 to 15	1.94	1.97	2.02	1.98	26 to 5	2.33	....	2.5[illegible]	1.[illegible]
11 to 20	1.94	2.03	2.09	1.98	Oct. 1 to 10	2.47	....	2.[illegible]	1.[illegible]
16 to 25	1.95	2.10	2.25	1.94	6 to 15	2.54	....	2.94	1.9[illegible]
21 to 30	1.98	2.17	2.26	1.92	11 to 20	2.41	....	....	2.0[illegible]
26 to 5	1.97	2.24	2.24	1.92	16 to 25	2.37	....	....	2.1[illegible]
Aug. 1 to 10	1.97	2.36	2.23	1.85	21 to 30	2.53	....	....	2.21
6 to 15	2.02	2.38	2.26	1.84	26 to 5	2.64	....	....	2.1[illegible]
11 to 20	2.05	2.44	2.31	1.93	Nov. 1 to 10	2.69	....	....	....
16 to 25	2.10	2.46	2.43	1.95	6 to 15	2.73	....	....	....
21 to 30	2.14	2.54	2.49	1.[illegible]	11 to 20	2.79	....	....	....
26 to 5	2.18	2.55	2.48	1.[illegible]					

In the meteorological report is given the evaporation at all the known points. The past year I made as extended observations as possible of the difference between the evaporation in the river and that on the land, at the meteorological observatories.

These observations were somewhat difficult to take, as the river evaporator had to be carefully watched to keep it from slopping. As the water in it was constantly in motion the evaporation was probably somewhat less than if it had been still, and, as the evaporation at the river stations was larger than that at the other stations on the lakes, the ratio between the evaporators given in the table is taken as correct for the whole lakes, though, on account of the temperature being greater in the river than on the lake surface generally, it should otherwise be somewhat reduced.

TABLE XXXIX.—*Showing the difference between the simultaneous readings of an evaporator at the meteorological station and one placed in the river St. Clair*, 1868.

Date.	Evaporation. Land.	Evaporation. River.	Evaporation. Difference.	Date.	Evaporation. Land.	Evaporation. River.	Evaporation. Difference.
August 10	.085	.079	+.006	August 24	.191	.081	+.110
11	.049	.014	+.035	24 (night)	.052	.030	+.022
12	.182	.137	+.045	25	.180	.068	+.112
12, (night)	.119	.095	+.024	25 (night)	.045	.059	+.014
13, (night)	.058	.058	+.000	26 (night)	.050	.017	+.033
14	.260	.125	+.135	28	.181	.050	+.131
14, (night)	.082	.040	+.042	28 (night)	.103	.045	+.058
15	.128	.056	+.072	29	.140	.046	+.094
16	.195	.105	+.090	30	.186	.124	+.062
17	.199	.060	+.139	Septe'r 3	.103	.045	+.058
18, 19	.287	.171	+.116	9	.095	.026	+.069
21	.220	.151	+.069	10	.167	.035	+.132
21, (night)	.020	.056	—.036	14	.176	.078	+.098
22	.190	.042	+.148	Sums	4.039	1.997	+2.042
22, (night)	.017	.028	—.011				
23	.279	.076	+.203	Means	.134	.066	.068

TABLE XL.—*Showing the difference between the simultaneous readings of an evaporator at the meteorological station and one placed in the river Niagara*, 1868.

Date.	Evaporation. Land.	Evaporation. River.	Evaporation. Difference.	Date.	Evaporation. Land.	Evaporation. River.	Evaporation. Difference.
June 19	.289	.104	+.185	August 26	.199	.089	+.119
20	.189	.067	.131	28	.177	.110	.067
21	.175	.074	.101	Septe'r 1	.204	.099	.105
30	.230	.043	.187	2	.158	.116	.042
July 16	.304	.174	.130	8	.152	.095	.057
17	.285	.080	.205	11	.121	.046	.075
24	.134	.074	.060				
25	.310	.066	.244	Sums	3.523	1.542	+1.981
Aug. 5	.283	.080	.203				
24	.086	.063	.023	Means	.207	.091	.117
25	.218	.171	.047				

TABLE XLI.—*Showing the difference between the simultaneous readings of an evaporator at the meteorological station and one placed in the river St. Lawrence, 1868.*

Date.	Evaporation. Land.	Evaporation. River.	Evaporation. Difference.	Date.	Evaporation. Land.	Evaporation. River.	Evaporation. Difference.
June 9	.1410	.0083	+.1327	Aug. 10	.1048	.0876	+.0172
10	.1330	.1137	.0193	11	.0291	.0530	—.0239
11	.2328	.0028	.2300	12	.3124	.1367	+.1757
12	.3172	.1480	.1692	13	.2200	.1992	.0208
13	.2686	.1375	.1311	14	.3632	.1636	+.1996
14	.2428	.0725	.1703	15	.1960	.1372	.0588
15	.2154	.0900	.1254	16	.1301	.1083	.0218
16	.2145	.1075	.1070	17	.1441	.0686	.0755
17	.2437	.0425	.2012	18	.2300	.2141	.0159
18	.2493	.1175	.1318	19	.1987	.1028	.0959
19	.2635	.1655	.0980	20	.0751	.0164	.0587
20	.1958	.0722	.1236	21	.1749	.1377	.0372
21	.3964	.1898	.2066	22	.3606	.1851	.1755
22	.0131	.0372	—.0241	23	.1283	.2642	—.1359
23	.1566	.0410	+.1156	24	.2468	.1085	+.1383
24	.2317	.2939	—.0622	25	.1847	.1962	—.0115
25	.1384	.1412	—.0028	26	.1400	.1400	.0000
26	.2911	.1335	+.1576	27	.3622	.1588	+.2034
27	.2640	.1689	.0951	28	.2416	.1884	.0532
28	.2366	.1158	.1508	29	.2760	.1192	.1568
29	.2273	.1239	.1034	30	.2240	.1373	.0867
30	.1344	.0659	.0685	Sept. 1	.2533	.0314	.2219
July 1	.2412	.1428	.0984	2	.2650	.1533	.1017
2	.2569	.1777	.0792	3	.1557	.0618	.0939
3	.2692	.0810	.1882	4	.0120	.0378	—.0258
4	.3134	.0591	.2543	5	.2203	.1438	+.0765
5	.4241	.1481	.2760	6	.2412	.2132	.0280
6	.3198	.0404	.2794	7	.1075	.0457	.0618
8	.2098	.1033	.1065	8	.1919	.1115	.0804
9	.2793	.0999	.1794	9	.0802	.0375	+.0427
10	.3134	.0942	+.2192	10	.1066	.0837	.0229
11	.2858	.1116	.1742	11	.1885	.0610	.1275
12	.2669	.1391	.1278	12	.1952	.0854	.1098
13	.2620	.1826	.0794	13	.2271	.1092	.1179
14	.3008	.1858	.1150	14	.2107	.1077	.1030
15	.2671	.1009	.1662	15	.3107	.1704	.1403
16	.4067	.1955	.2112	16	.2734	.1104	.1630
17	.2294	.1363	.0931	17	.1514	.1074	.0440
18	.2586	.1284	.1302	18	.1087	.1486	—.0399
19	.1538	.1051	.0487	19	.1401	.1480	—.0079
20	.2142	.1454	.0688	20	.0890	.0270	+.0620
21	.4320	.1136	.3184	21	.1290	.1216	.0074
22	.3246	.0806	.2440	22	.1013	.0430	.0583
23	.1621	.0757	.0864	23	.1167	.0738	.0429
24	.2041	.2381	—.0340	24	.0819	.1509	—.0690
25	.2053	.1235	+.0818	25	.0414	.0172	+.0242
26	.1603	.2158	—.0555	26	.1132	.0706	.0426
27	.1144	.0837	+.0307	27	.1018	.0551	.0467
28	.2232	.1222	.1010	29	.3255	.0711	.2544
29	.0533	.0398	.0135	30	.0581	.0585	—.0004
30	.0810	.1166	—.0356	Oct. 1	.1379	.0755	+.0624
31	.1875	.0300	+.1575	2	.0885	.0322	.0563
Aug. 1	.1470	.1112	.0358	3	.1228	.1055	.0173
2	.2385	.0560	.1825	4	.1572	.0655	.0917
3	.2715	.0950	.1765	5	.0564	.0998	—.0434
4	.3415	.1115	.2300	6	.1393	.0667	+.0726
5	.1922	.2175	—.0253	Sums ...	24.2179	13.2633	+10.9546
6	.2874	.1611	+.1263				
7	.2574	.1537	.1037	Means ..	0.2069	0.1133	+0.0936
8	.2852	.0946	.1906				
9	.2977	.2321	+.0656				

The following tables are similar to those given last year, but corrected according to this year's observations.

The outflow of the Ste. Marie is decreased 10 per cent., and the outflow of the Niagara corrected for the error arising from having only made observations during the summer months.

This correction was made by taking the outflow for June as maximum for the year, and that the minimum was proportionate to the fall in the water at Buffalo.

The amount of rain-fall is taken from table XXXVII, and the evaporation from the Report on Meteorology, corrected by the ratio given in table.

The outflow is a little less than half the total rain-fall, and a little more than half the rain-fall less the evaporation.

This, as noticed in the last report, is very large, and would seem to indicate other sources of supply.

TABLE XLII.—*Showing the amount of rain-fall on lake surface and water shed, and the ratio between it and the outflow at the several stations,* 1868.

Section.	Water-shed and lake surface — sq. miles.	Daily rain-fall—inches.	Daily rain-fall on water-shed and lake surface—cubic feet.	Rain-fall on water-shed and lake surface per second — cubic feet.	Rain-fall per second in each section—cubic feet.	Discharge per second in each section—cubic feet.	Ratio of rain-fall and discharge.
Lake Superior	90, 505	0. 0770	16, 190, 113, 632	187, 386	187, 386	80, 870	0. 43
Lakes Michigan and Huron	121, 941	0. 0802	22, 720, 125, 162	262, 964	450, 350	216, 435	0. 48
Lake Erie	40, 298	0. 0892	8, 350, 931, 973	96, 654	547, 004	235, 678	0. 43
Lake Ontario	31, 558	0. 0892	6, 539, 746, 667	75, 692	622, 696	272, 095	0. 44

TABLE XLIII.—*Showing the amount of rain-fall, less the evaporation from the lake surface, and the ratio between it and the out-flow at the several stations,* 1868.

Section.	Lake surface—square miles.	Daily evaporation—inches.	Daily evaporation from lake superior—cubic feet.	Evaporation from lake surface per second—cubic feet.	Rain-fall per second, less evaporation in each section—cubic feet.	Discharge per second in each section—cubic feet.	Ratio.
Lake Superior	38, 875	0. 033	2, 980, 375, 200	34, 495	153, 091	80, 870	0. 53
Lakes Michigan and Huron	51, 721	0. 048	5, 767, 594, 906	66, 754	349, 101	216, 435	0. 62
Lake Erie	10, 114	0. 051	1, 198, 339, 085	13, 870	431, 885	235, 678	0. 55
Lake Ontario	8, 021	0. 049	913, 084, 973	10, 568	497, 009	272, 095	0. 55

I wish to express my thanks to my assistants for the faithful manner in which they performed their duties, and especially to Assistant Flint, without whose valuable aid, in the field and office, the work would have been much less complete.

I hope, at the end of this season, to be able to report more fully in relation to the form of the curves, the agreement of the observations with the old formula, and on the pulsations.

TABLE A.—*Daily observations for velocity of current in the St. Clair River,* 1868.

VERTICAL.

Date.		Distance from base, in feet.	Wind in direction of river, in miles per hour.	Depth of river.	Mean time run in minutes.	Observed velocity of river at the following depths: 0	5	10	15	20	25	30	35	40	45
June	27	111	D 1.8	8	21	1.123	......	......	......	......	......	......	......	......	......
	27	561	D 4.35	45	10	3.875	4.464	4.396	4.137	3.978	3.985	3.731	3.612	2.57[illegible]	......
	27	184	D 1.4	21	20	......	1.880	1.928	1.671	(18) 1.227	......	......	......	......	......
	29	844	U 8.0	55	10	3.777	3.900	3.819	3.762	3.691	3.641	3.600	3.353	3.094	2.8[illegible]
	29	1,010	U 8.0	53	10	......	4.244	4.264	4.148	4.045	4.040	3.814	3.718	3.521	3.2[illegible]
	30	1,155	U 7.5	53	10	......	4.032	3.832	3.733	3.620	3.426	3.308	3.167	2.884	2.4[illegible]
	30	1,357	U 8.2	45	10	2.521	3.456	3.338	3.159	3.101	2.968	2.879	2.572	2.107	......
July	1	1,294	U 6.8	48	10	2.880	3.541	3.515	3.309	3.185	3.169	2.929	2.565	2.159	......
	1	1,294	U 3.5	48	6	......	3.228	3.524	3.429	3.216	2.978	2.946	2.643	2.225	......
	2	1,477	U 4.5	38	10	2.868	2.914	2.828	2.471	2.513	2.182	1.825	(32 ft) 1.621	......	......
	2	1,639	U 5.0	27	10	2.080	2.114	2.225	1.911	1.883	1.487	......	......	......	......
	8	130	D 8.9	10	10	1.473	1.111	......	......	......	......	......	......	......	......
	8	328	D 10.0	41	10	3.980	4.443	3.976	3.890	3.806	3.439	3.114	2.598	......	......
	8	218	D 8.9	30	10	3.070	3.158	3.038	3.062	2.691	(24) 2.142	......	......	......	......
	9	372	D 9.0	42	10	4.042	4.453	4.338	4.152	4.034	3.970	3.627	3.248	......	......
	9	512	D 8.2	45	10	3.998	4.470	4.524	4.418	4.238	3.948	3.900	3.506	2.860	......
	9	604	D 10.0	48	5	......	4.331	4.373	4.196	4.026	3.409	......	......	......	......
	10	508	U 0.71	43	10	4.005	4.518	4.379	4.204	4.060	3.890	......	......	......	......
	16	724	D 9.0	46	10	4.295	4.471	4.381	4.074	4.105	3.998	3.811	3.786	3.270	......
	16	729	D 7.2	46	10	4.144	4.501	4.227	4.221	4.106	4.035	3.771	......	......	......
	18	802	U 3.0	53	5	3.978	4.165	4.089	4.045	3.906	3.819	3.682	3.465	3.301	2.7[illegible]
	20	1,002	U 2.0	54	10	......	4.200	4.239	4.156	......	......	......	......	......	......
	20	942	U 2.0	54	5	......	......	......	......	4.133	3.846	3.773	3.588	3.580	3.31[illegible]
	20	955	U 4.5	52	10	......	4.127	4.020	3.958	3.828	3.814	3.632	3.603	3.216	3.1[illegible]
	21	1,093	D 5.0	51	10	......	4.135	3.873	3.813	3.821	3.544	3.465	3.212	3.168	2.[illegible]
	21	1,202	D 7.5	46	5	......	3.845	3.778	3.732	3.655	3.511	3.247	3.178	2.985	......
	22	1,211	D 8.3	45	6	3.707	3.944	3.871	3.825	3.491	3.421	3.288	3.057	2.920	2.[illegible]
	22	1,367	D 3.6	42	5	......	3.544	3.534	3.471	3.425	3.121	2.775	2.532	1.678	......
	22	1,393	D 7.3	41	5	......	3.462	3.388	3.226	3.080	3.057	2.471	2.241	......	......
	22	1,458	D 12.4	38	5	......	3.128	3.078	2.901	2.670	1.886	1.720	(33) 1.501	......	......
	24	1,268	D 16.0	45	5	3.429	3.732	3.858	3.626	3.598	3.473	3.301	2.725	2.49[illegible]	2.312
	24	1,619	D 18.0	29	5	......	2.701	2.710	2.604	2.225	2.051	......	......	......	......
	25	322	D 6.7	38	5	3.883	4.126	3.962	3.894	3.572	3.355	3.175	2.610	......	......
	25	192	D 6.2	23	5	2.736	2.793	2.738	2.246	2.004	......	......	......	......	......
	27	392	D 2.4	43	10	4.173	4.119	3.095	3.841	3.744	3.717	3.620	3.098	(37) 2.771	......
	27	510	U 1.6	43	5	4.212	4.536	4.420	4.168	4.076	4.089	3.860	3.551	(37) 3.267	......
	27	565	U 2.4	44	5	......	4.492	4.267	4.297	{3.940 / 4.270}	3.998	3.725	3.511	2.616	......
	28	689	D 8.9	47	5	......	4.266	4.278	4.215	4.064	3.957	3.586	3.575	......	......
	28	690	D 2.5	47	5	4.168	4.364	4.121	3.942	3.703	3.645	3.624	3.282	3.[illegible]	3.10[illegible]
	28	779	D 8.5	52	5	......	4.226	4.075	3.970	3.955	3.896	3.773	3.659	3.244	3.2[illegible]
	30	929	U 5.2	54	5	3.768	4.248	4.059	3.942	4.029	4.017	......	......	......	......
	30	953	U 3.2	54	10	3.968	4.038	4.018	3.836	3.699	3.819	3.632	3.601	3.418	2.9[illegible]
Aug.	5	1,349	U 2.6	40	5	3.541	3.572	3.544	3.365	3.349	3.001	2.970	2.535	(38) 2.060	......
	6	958	U 5.0	54	5	4.098	4.112	4.106	4.123	3.972	3.659	3.670	3.601	3.471	3.270
	6	1,087	U 11.3	51	5	......	3.949	3.914	3.871	3.821	3.580	3.536	3.580	3.075	2.710
	7	1,227	U 12.5	48	5	......	3.601	3.581	3.178	3.365	3.357	3.041	2.814	2.391	......
	7	1,241	U 13.3	45	5	......	3.498	3.313	3.341	3.116	2.968	2.788	2.710	1.847	......
	11	1,349	D 5.0	44	5	......	3.481	3.378	3.298	3.229	3.049	2.704	2.494	1.98[illegible]	......
	11	1,453	D 5.0	39	5	2.731	3.024	2.872	2.820	2.419	2.266	2.060	(33) 1.897	......	......
	11	1,521	D 9.8	30	5	......	2.933	2.813	2.555	2.364	1.889	......	......	......	......
	11	1,734	D 10.4	10	5	......	1.175	......	......	......	......	......	......	......	......
	11	1,653	D 9.8	29	5	......	2.581	2.279	2.200	2.072	1.548	......	......	......	......
	12	122	D 7.1	8	11	......	(8) 1.065	......	......	......	......	......	......	......	......
	13	307	D 1.2	37	5	2.959	3.766	3.518	3.452	3.370	3.216	2.912	......	......	......
	13	198	U 0.4	22	5	2.678	2.832	2.720	2.604	2.170	......	......	......	......	......

TABLE A.—*Daily observations for velocity of current, &c.*—Continued.

Date.		Distance from base, in feet.	Wind in direction of river, in miles per hour.	Depth of river.	Mean time run in minutes.	Observed velocity of river at the following depths:									
						0	5	10	15	20	25	30	35	40	45
Aug.	13	397	D 1.5	43	5	......	4.213	4.303	4.185	4.003	3.788	3.531	2.975	(38) 2.951	......
	13	531	U 0.8	43	5	......	4.448	4.306	4.165	4.054	3.870	3.727	3.351	(38) 2.851	......
	14	596	D 2.1	46	5	3.786	4.110	4.131	3.998	3.901	3.721	3.549	3.198	2.397	......
	14	806	D 2.4	53	5	......	4.165	3.998	3.972	3.957	2.786	3.486	3.442	3.341	3.239
	14	901	U 0.8	54	5	......	3.996	4.022	3.921	3.894	3.709	3.703	3.570	3.375	3.211
	14	1,508	U 0.6	36	5	......	3.017	2.799	2.682	2.260	1.921	1.537	......	......	......
	15	1,003	U 0.5	53	5	3.298	4.101	4.031	3.898	3.814	3.796	3.572	3.531	3.241	2.643
	15	1,100	U 0.8	50	5	......	3.794	3.727	3.657	3.719	3.375	3.331	3.274	2.865	(44) 2.518
	17	1,151	U 1.5	48	5	......	3.978	3.728	3.665	3.505	3.308	3.324	3.301	2.691	(44) 2.114
	17	1,273	U 5.7	46	5	......	3.693	3.672	3.570	3.511	3.255	3.134	3.078	1.955	......
	17	1,711	U 8.5	21	5	......	1.311	1.276	1.073	(12) 1.967	......	......	......	......	......
	17	1,310	U 8.0	45	5	3.187	3.649	3.608	3.588	3.435	3.305	3.063	2.756	1.936	......
	21	208	D 10.6	27	5	......	3.063	2.845	2.710	2.638	......	......	......	......	......
	22	529	D 0.5	46	5	4.011	4.470	......	4.089	......	3.601	......	3.150	(38) 3.072	......
	22	1,411	U 0.7	42	5	3.021	3.049	3.124	2.963	2.883	2.663	2.233	1.666	......	......
	22	1,379	D 4.0	42	5	......	3.378	3.256	3.188	2.907	2.820	2.376	2.347	(37) 1.691	......
	22	1,490	D 6.2												
	25	170	U 4.8	35	5	2.543	2.868	2.807	2.643	2.307	1.913	(28) 1.736	......	......	......
		(2)		19	5	1.645	1.895	1.813	1.422	......	......	......	......	......	......
	25	378	U 5.7	43	5	3.678	4.135	3.858	3.845	3.649	3.452	3.285	2,775	......	......
	25	......	....	....	....	......	4.215	4.166	......	......	......	......	......	......	......
	25	(2) 444	U 5.7	46	5	3.750	4.328	4.331	4.081	4.053	3.925	3.711	3.278	(38) 3.075	......
	25	254	U 4.8	31	5	......	3.378	3.282	3.171	3.075	2.701	(27) 2.271	......	......	......
	26	547	D 14.2	43	5	......	4.381	4.314	4.215	4.110	3.896	3.693	3.263	(38) 3.255	......
Sept.	1	395	D 3.9	44	5	......	4.345	4.224	4.081	3.997	3.898	3.639	3.261	......	......
	1	467	D 8.0	44	5	......	4.334	4.259	4.080	4.032	3.787	3.717	3.482	(37) 3.142	......
	2	1,309	U 0.3	43	16	......	3.228	3.216	3.101	2.858	2.824	2.804	......	......	......
	2	1,542	U 8.0	29	21	......	2.601	2.425	2.258	1.839	......	......	......	......	......
	4	1,044	U 0.6	49	14	......	4.119	4.181	4.179	3.851	3.694	3.716	3.577	3.343	(43) 3.219
	9	140	U 5.7	12	5	......	1.415	......	......	......	......	......	......	......	......
	9	244	U 8.5	30	3	......	3.093	2.916	2.846	2.626	2.307	(27) 2.137	......	......	......
	10	378	U 3.2	43	2	3.687	4.067	3.825	3.935	3.709	3.678	3.198	2.808	......	......
	10	1,240	U 3.5	46	2	......	3.549	3.435	3.324	3.101	3.043	2.808	2.886	2.028	......
	10	1,240	U 3.5	46	5	......	......	3.462	3.435	3.365	3.191	3.151	2.761	......	......
	11	1,042	D 8.4	49	5	3.794	4.129	4.086	4.137	4.018	3.819	3.948	3.750	3.365	(43) 3.331
	11	1,042	D 8.4	49	5	3.898	4.076	4.193	4.026	3.929	3.886	3.749	2.665	3.427	......
	12	1,657	U 5.7	28	3	......	2.046	1.916	1.838	1.885	1.348	......	......	......	......
	12	1,657	U 5.7	28	5	......	......	2.063	2.147	1.913	1.333	......	......	......	......
	12	1,249	U 8.5	44	3	3.456	3.686	3.660	3.639	3.237	3.280	3.100	2.710	......	......
	14	487	U 5.0	45	3	3.370	4.057	4.026	3.930	3.871	3.798	3.498	2.972	(39) 2.778	......
	14	735	U 1.5	49	3	......	4.108	3.913	3.854	3.828	3.686	3.635	3.331	3.207	(43) 2.137
	16	134	D 2.5	8	5	1.515	(3) 1.395	......	......	......	......	......	......	......	......
	16	1,742	D 2.5	7	12	(2) 1.247	......	......	......	......	......	......	......	......	......
	17	458	D 2.2	44	3	3.998	4.431	4.183	4.244	3.891	4.174	3.828	3.524	(38) 2.786	......
	17	1,065	D 3.1	50	3	......	4.067	3.806	3.936	3.849	3.704	3.297	3.122	2.922	(44) 2.920

TABLE A.—*Daily observations for velocity of current, &c.*—Continued.

HORIZONTAL.

Date.		Distance from base in feet.	Wind in direction of river in miles per hour.	Depth of river.	Mean time run in minutes.	Observed velocity of river at the following depths: 0	5	10	15	20	25	30	35	40	45
July	7	245	U 3.6	30	10	......	2.853	3.217	......	......	......	......	......	......	......
	7	369	U 3.2	40	10	......	4.741	4.406	......	......	......	......	......	......	......
	7	643	U 2.7	42	10	......	4.239	3.994	......	......	......	......	......	......	......
	7	936	D 10.9	54	10	......	4.112	4.235	......	......	......	......	......	......	......
	7	1,195	D 10.9	47	10	......	4.022	3.783	......	......	......	......	......	......	......
	7	1,300	D 11.0	43	10	......	3.549	3.470	......	......	......	......	......	......	......
	7	1,639	D 11.5	27	10	......	2.488	2.452	......	......	......	......	......	......	......
	29	271	U 1.0	38	5	......	......	......	3.596	3.336	3.117	......	......	......	......
	29	499	— 0.0	43	5	......	......	......	4.102	3.898	3.917	......	......	......	......
	29	698	— 0.0	47	5	......	......	......	4.270	3.970	3.755	......	......	......	......
	29	970	U 2.2	54	5	......	......	......	3.927	3.852	3.768	......	......	......	......
	29	1,107	D 0.6	48	5	......	......	......	3.345	3.674	3.494	......	......	......	......
	29	1,254	D 0.0	45	5	......	......	......	3.639	3.533	3.403	......	......	......	......
	29	1,376	D 0.0	42	5	......	......	......	3.024	2.860	2.688	......	......	......	......
	29	1,564	U 6.6	28	5	......	......	......	2.238	1.848	1.590	......	......	......	......
Aug.	10	301	U 0.0	36	5	......	......	......	......	......	......	2.552	......	......	......
	10	488	U 0.0	43	5	......	......	......	......	......	......	3.698	3.524	(m) 2.878	......
	10	688	U 0.3	47	5	......	......	......	......	......	......	3.621	3.480	3.186	(m) 2.[illegible]
	10	947	U 0.4	54	5	......	......	......	......	......	......	3.832	3.565	3.411	......
	10	1,093	D 1.1	51	5	......	......	......	......	......	......	3.259	3.301	3.175	2.731
	10	1,253	D 1.0	45	5	......	......	......	......	......	......	3.370	2.805	2.334	......
	10	1,393	D 0.0	42	5	......	......	......	......	......	......	2.488	1.921	......	......
	12	295	D 7.1	35	5	......	3.665	3.682	3.616	3.172	......	......	......	......	......
	12	536	D 1.8	44	5	......	4.489	4.497	4.259	4.221	......	......	......	......	......
	12	714	D 7.0	48	5	......	4.284	4.289	4.165	4.026	......	......	......	......	......
	12	894	D 15.0	54	5	......	4.267	4.303	4.160	3.957	......	......	......	......	......
	12	1,181	D 12.3	49	5	......	3.852	3.690	3.685	3.631	......	......	......	......	......
	12	1,414	D 10.0	42	5	......	3.229	3.217	3.024	2.900	......	......	......	......	......
	24	286	U 2.2	35	5	......	......	......	......	......	3.036	2.586	......	......	......
	24	484	U 2.0	43	5	......	......	......	......	......	3.883	3.742	3.447	......	......
	24	749	U 2.0	51	5	......	......	......	......	......	3.713	3.605	3.357	......	......
	24	896	U 2.0	54	5	......	......	......	......	......	3.768	3.758	3.501	......	......
	24	993	U 0.0	52	5	......	......	......	......	......	3.819	3.696	3.565	......	......
	24	1,268	U 10.5	45	5	......	......	......	......	......	3.293	3.221	2.840	......	......
	24	1,413	U 9.0	40	5	......	......	......	......	......	2.659	2.282	1.562	......	......
	24	1,636	U 2.5	30	5	......	......	......	......	......	1.770	......	......	......	......
	26	466	D 1.0	44	10	......	......	......	......	......	......	......	......	(m) 2.602	......
	26	696	U 4.5	47	5	......	......	......	......	......	......	......	......	2.980	(m) 2.904
	26	896	U 4.5	54	5	......	......	......	......	......	......	......	......	3.567	3.447
	26	896	....	54	5	......	......	......	......	......	......	......	......	......	(m) 2.841
	26	1,026	U 6.6	52	6	......	......	......	......	......	......	......	......	3.339	2.946
	26	1,026	....	52	6	......	......	......	......	......	......	......	......	......	(m) 2.[illegible]
	26	1,209	U 6.0	47	5	......	......	......	......	......	......	......	......	2.599	(m) 2.040

TABLE A.—*Daily observations for velocity of current in the Niagara River*, 1868.

VERTICAL.

Date.		Distance from base.	Wind in direction of river—Miles per hour.	Depth of river.	Mean time in minutes.	Observed velocity of river at the following depths:														
						1–2	5	10	15	20	25	30	35	40	45	50	55	60	65	70
June	10	82		30	15	2.039	2.050	2.146	2.396	2.206	1.781									
	11	194		52	15	2.663	2.700	2.789	2.817											
	11	43		18	15	2.162	1.900	(8) 2.299												
	11	37		12	5	1.953	2.070	(8) 2.150												
	11	28		6	4	2.177	(2 1-2) 2.220	(4 1-2) 1.832												
	11	20		3	2	1.940														
	11	12		2	4	(1-2) 0.720														
	12	1,840		1	2	(1-2) 1.034														
	12	1,830		3	6	1.886														
	12	1,803		15	30	2.398	2.364	2.824	(13) 2.265											
	12	1,783		22	15	2.673	3.017	2.926	2.772											
	12	1,751		37	5	3.472	3.353	3.007	2.618	1.710										
	13	110		36	10	2.635	2.292	2.456	2.393	2.167	1.904									
	13	165		53	30	2.776	2.596	2.833												
	13	24		5	15	1.714														
	15	390		77	5	3.883	3.578	3.966												
	19	250	D 3.25	66	18								3.440	3.033						
	20	216	U 4.00	62	40												2.192			
	20	192		57	15		3.175	3.214	2.974	3.191	3.152	3.307	3.357	3.061	3.172	2.574				
	22	180	D 3.50	56	25	2.468	2.394	2.847	2.573	2.730			2.789	2.093	2.242	1.796				
	23	1,519	D 8.0	50	30		3.943	3.828	3.863	3.567	3.264	3.438	3.447	3.373	2.850					
	24	1,486	U 10.4	49	30		4.016	3.603	3.484	3.854	3.939	3.632	3.463	3.377						
	25	1,089	U 6.0	53	10	3.889	4.022	4.774	4.470	3.844	3.760	3.710	3.760	3.807						
	26	1,009	U 4.5	53	25	3.916	4.284	4.560	4.418	4.268	4.202	3.899	3.483	3.627	3.318					
	27	740	D 3.3	57	30	4.769	4.374	4.677	4.304	4.680	4.412	4.119	3.969	3.655	3.286					
	29	660	D 3.9	57	20	4.746	4.682	4.087	3.707	4.551	4.220	3.857	3.676	(37) 3.553						
	30	1,486		49	13										2.185					
	30	1,552	D 7.9	50	25	3.432	3.543	3.620	3.877	3.350	3.200	3.343	3.129	3.123	2.162					

TABLE A.—*Daily observations for velocity of current in the Niagara River*, 1868—Continued.

VERTICAL.

Date.		Distance from base.	Wind in direction of river—Miles per hour.	Depth of river.	Mean time in minutes.	Observed velocity of river at following depths:														
						1–2	5	10	15	20	25	30	35	40	45	50	55	60	65	70
July	1	1,621	D 3.5	48	30		3.455	3.445	2.859	2.683	3.053	3.150	2.734	2.698	(44) 1.518					
	2	1,685	D 3.8	46	30	2.391	3.246	3.370	2.951	2.619	2.844	2.392	2.543	1.744						
	3	1,370	D 5.3	48	20	4.147	4.045	4.074	4.060	3.981	3.485	3.938	3.400	3.323	2.791					
	6	1,309	U 4.0	48	30	4.087	3.946	4.117	4.194	4.073	3.747	4.181	4.037	3.690						
	7	1,130	U 7.8	53	23	4.339	4.124	4.239	4.144	4.256	4.134	3.875	3.657	3.137	2.806	2.781				
	8	1,200	D 8.5	49	20	4.294	4.276	4.200	4.165	4.088	4.246	3.790	3.625	3.327	3.057					
	9	581	U 10.5	59	20									3.722	3.979	3.285	3.705			
	10	570	U 8.5	60	20										3.775	3.337	3.555			
	11	616	U 4.7	58	20	4.121	4.458	4.198	4.153	3.973	4.260	3.977	4.416	3.899	3.648	3.402	2.728			
	13	679	U 3.2	61	25	4.478	4.105	4.446	4.085	4.410	4.055	4.170	4.250	3.932	4.002	3.720	3.528	3.453		
	14	272	D 2.3	68	30	3.833	3.350	3.355	3.800	3.362	3.320	3.385	3.115	3.273	2.980	2.763	2.990	2.393	1.910	
	15	375	U 5.0	71	30	3.353	4.190	3.930	3.928	4.268	3.695	3.910	3.833	4.040	3.658	3.540	3.188	3.235	2.833	
	16	130	U 3.0	41	30	2.060	2.578	2.000	2.453	1.683	2.170	1.923								
	16	76	U 2.7	29	30		1.858	2.210	2.248	2.022	1.725									
	18	1,810	U 2.0	15	50	2.118	1.990	2.327												
	18	1,770	D 4.9	29	30		3.118	2.780	2.830	2.800	2.568									
	20	40	D 4.6	13	60	1.798	1.908	1.888												
	20	20	D 9.0	3	60	1.040														
	20	80	D 3.6	30	30	2.100	1.915	1.928	2.315	1.905	1.640									
	27	1,699	U 0.8	45	30	2.668	3.027	2.761	2.933	2.715	2.600	2.386	2.031							
	29	335	?...............	72	15	3.889	4.220	4.332	4.102	3.840	3.808	3.926	3.689	3.323	3.453	3.096				
Aug.	4	926	....	54	30		3.388	3.845	3.815	3.952	3.867	3.627	3.349	2.888	2.866	2.563				
	5	663	U 5.8	60	40		4.012	4.116	4.220	4.009	3.599	3.506	3.402	3.381	3.207	([illegible]) 3.002				
	8	725	D 19.2	58	40						3.677	3.468	3.465	3.235	3.155					
	10	1,701	U 3.7	45	60		2.664	2.891	2.642	2.104	2.355	2.298	1.570							
	13	1,660	?...............	47	35	2.458	2.592	2.838	2.307	2.442	2.152	2.210	1.820	([illegible]) 1.875						
	14	1,508	D 7.5	49	40					2.518	2.770	2.780	2.385	2.332	2.081					
	15	1,606	D 11.3	48	45	2.919	2.838	2.812	2.766	2.497	2.467	2.479	2.636	2.104						
											Wind	U								
	18	1,444	D 18.5	48	40		2.927	2.947	3.066	3.092	3.010	2.624	2.780	2.430						
	19	1,535	D 10.8	50	30		2.493	2.638	2.809	2.968	2.504	2.743	2.592	2.468						
	20	1,544	U 6.4	50	40	2.314	2.379	2.703	2.448	2.798	2.300	2.487	2.038	2.347						

	30	1,800		16	58			1.850													
	31	904	Change	54	40	3.494	3.627	3.820	3.585	3.431	3.234	3.073	3.148	2.659	2.370						
Sept.	1	1,427	0	48	40	3.088	3.071	3.394	3.053	2.893	3.049	3.057	2.764	2.456	2.398						
	2	1,364	U 9.0	48	40		3.228	3.164	2.964	2.952	3.223	3.019	2.834	2.548	1.894						
	3	1,238	D 9.8	48	40	3.158	3.416	3.293	3.060	3.504	3.205	2.980	2.728	2.594	2.164						
	4	1,128	D 6.7	53	35	3.583	3.627	3.710	3.479	3.290	3.205	2.969	2.848	2.623	2.327						
	5	1,027	West	53	40	3.409	3.485	3.600	3.540	3.635	3.577	3.310	3.088	2.921	2.452						
	7	147	0	51	147		2.089														
	8	1,729	D 9.1	42	306		2.276														
	8	1,729	D 9.1	42	85			2.294													
	9	1,500	U	49	391		3.025														
	10	1,612	U 2.4	48	170		2.190														
	10	1,612	0	48	24			2.168													
	11	639	D 3.7	62	40		3.405	3.355	3.583	3.230	3.257	3.142	2.979	2.860	2.678	2.468					
												U 4.0		U 4.0		D 7.4	W. 0 (54)				
	12	506		68							3.442	3.933	3.709	3.422	3.179	3.023	2.888				
	14	294	U 11.0	68	30									2.686	2.918	3.066	2.579				
	15	436	D 12.5	72	30		3.099	3.478	3.607	3.559	3.463	3.422	3.605	3.269	3.079	3.122	3.938				
	17	687	D 8.8	56	40							2.672	2.797	2.728							
July	24	165	D 5.5	53	318		2.171														
	24	540	D 3.0	60	53		4.140														
	25	640	0	63	117		4.485														
	29	335		72	30		4.301														
Aug.	13	593	D 13.2	57	162		4.358														
	13	60		27	197		2.836														

TABLE A.—*Daily observations for velocity of current in the Niagara River*, 1868

HORIZONTAL.

Date.	Depth of obs.	Wind in direction of river.	Mean time in minutes.	Velocities at the following distances from base:									
				39	1.166	1.372	1.544						
July 17	5	0	30	2.158	4.233	3.465	3.480						
				99	248	343	504	729	973	1.244	1.544	1.715	
July 22	5	U............3.6	30	2.425	3.025	4.098	4.198	3.994	4.158	3.923	3.088	3.058	
								741	908	1.090	1.268	1.510	1.685
July 23	5	U............5.3	40					4.138	4.270	4.063	3.973	3.468	2.785
				W. D. $_{6.5}$	Wind D. $_{8.5}$		Wind D. $_{8.0}$	Wind U. $_{3.9}$		Wind U. $_{5.7}$		Wind D. $_{2.7}$	
				123	300	521	685	932	1.107	1.262	1.459	1.677	
July 28	5	Change	40	2.847	3.907	4.719	4.406	4.360	4.343	4.215	3.807	3.139	
				144	321	523	616	910	1 106	1.262	1.471	1.632	
Aug. 3	5	U............5.1	50	2.479	3.691	4.248	4.318	4.265	3.999	3.754	3.489	2.602	
				145	341	530	715	839	1.180	1.302	1.424	1.699	
Aug. 6	10	U............4.1	50	2.214		3.653		3.594		3.424		2.378	
					W. D. $_{9.8}$		W. D. $_{7.4}$		W. U. $_{9.0}$		W. U. $_{4.1}$		
Aug. 7	10		60		3.048		4.212		3.783		3.199		
				216	524	711	903	1.183	1.327	1.546	1.717		
Aug. 22	20	U............3.8	30		3.487				2.912		2.079		
Aug. 24	20	0	70	3.190		3.216	3.334	3.235		2.541			
													Wind D. $_{2.2}$
				140	145	340	508	728	892	1.169	1.334	1.462	1.725
Aug. 25	25	U............5.0	100	1.977			3.149				3.186		2.026
						Wind U. $_{4.7}$		Wind=$_{0}$		Wind U. $_{3.0}$		Wind D. $_{2.1}$	
Aug. 26	25		70		1.696	3.019		3.342	3.377	3.201		2.810	
				145	471	702	852	1.091	1.332	1.533	1.744		
Aug. 27	30	U............2.8	.90	1.683					2.653		1.500		
Aug. 28	30	S............11.6	70		3.553	2.917	3.264	3.055		2.310			

TABLE A.—*Daily observations for velocity of current in the St. Lawrence River*, 1868.

VERTICAL.

Date.	Distance from base.	Wind in direction of river.	Depth of river.	Mean time run in minutes.	Observed velocity of river at the following depths: 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
June 15	587	D. 11.2	13	12		·0,737	0.575														
	878		23	9		1.075	0.974	0.854	(19) 0.300												
	1,088		25	6		1.483	1.267	1.180	0.996												
	1,283		27	6		1.654	1.506	1.283	1.123	0.794											
	1,540		51	5		1.698	1.681	1.621	1.458	1.453	1.373	1.374	1.098	0.512							
	1,860	D. 11.2	78	4		1.552	1.575	1.621	1.593	1.571	1.571	1.519	1.419	1.543	1.566	1.538	1.474	1.289	1.135		
	2,130		80	4		1.643	1.571	1.534	1.534	1.571	1.566	1.528	1,428	1.402	1.345	1.580	1.333	1.410	1.319	1.008	
	2,447	D. 0.9	70	5		1.689	1.582		1.526		1.645		1.479		1.311						
June 16	2,635	0	67	5		1.583	1.580	1.571	1.524	1.534	1.524	1.419	1.289	1.270	1.168	1.094					
	2,822		66	5		1.419	1.524	1.471	1.428	1.428	1.423	1.410	1.345	1.333	1.219	1.057					
	3,110	0	69	5		1.584	1.575	1.534	1.511	1.515	1.439	1.402	1.340	1.283	1.183	1.148	0.831				
	3,331		69	5		1.470	1.436	1.439	1,474	1.362	1.394	1.383	1.305	1.283	1.195	1.143	0.954				
	3,508	0	69	5		1.319	1.439	1.423	1.419	1.431	1.376	1.351	1.340	1.272	1.198	1.113	1.006				
June 17	3,750	D. 4.2	61	6		1.402	1.344	1.316	1.231	1.249	1.198	1.173	1.120	1.120	0.972	0.900					
	3,870		55	6		1.287	1.289	1.155	1.153	1.143	1.150	1.045	1.035	0.883							
	4,036		48	6		1.193	1.092		1.178		1.968		0.778								
	4,232	D. 11.6	41	10		0.617	0.827	0.810	0.842	0.775	0.739	0.674									
	4,394		30	8		0.681	0.625	0.621	0.598	0.450											
	4,511	D 7.0	17	12		0.646	0.718														
June 23	133	D. 10.4	3	19		(2) 0.300															
	300		5.5	14		(3) 0.575															
	461		7.5	9		(8) 0.425															
	647		14.5	14		0.694	0.460														
	814		21	11		0.954	0.758	0.619													
	995		23	8		1.295	1.164	1.000	0.877												
	1,198		26	5		1.590	1.545	1.448	1.108												
	1,418	0	36	6		1.672	1.609	1.590	1.511	1.346	1.239										
	1,621	0	64	6		1.618	1.627	1.590	1.609	1.582	1.534	1.534	1.445	1.366	1.337	1.082	0.854				
	1,863	0	79	6		1.560	1.645		1.534		1.519		1.560		1.511		1.445		1.056		
June 24	2,148	D. 7.7 U. 6.0	81	6		1.534	1.519	1.522		1.545	1.507	1.451	1.455	1.462	1.329	1.455	1.438	1.434	1.254	1.002	
	2,416	U. 8.0	71	7		1.493	1.534	1.483	1.534	1.403	1.389	1.496	1.421	1.414	1.234	1.228	1.180	1.224	0.718	1.011	

TABLE A.—*Daily observations for velocity of current in the St. Lawrence River, 1868*—Continued.

VERTICAL.

Date.	Distance from base.	Wind in direction of river.	Depth of river.	Mean time run in minutes.	Observed velocity of river at the following depths: 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
	2,590	U. 11.0	66	6	......	1.493	1.469	1.458	1.571	1.575	1.511	1.424	1.360	1.246	1.168	1.114	0.717	......	......	......	......
	2,900	0	65	6	......	1.380	1.458	1.406	1.448	1.574	1.383	1.357	1.314	1.270	1.128	1.076	0.928	......	......	......	......
	3,124	0	66	3	......	1.380	1.280	1.386	1.479	1.538	1.410	1.311	1.266	1.222	1.222	1.094	1.002	......	......	......	......
June 25	3,318	U. 2.1 D. 1.5	66	7	......	1.441	1.369	1.434	1.329	1.377	1.400	1.397	1.326	1.217	1.027	0.950	0.685	......	......	......	......
	3,515	......	66	7	......	1.406	1.298	1.303	1.323	1.334	1.148	1.182	1.234	1.234	1.052	1.024	0.966	......	......	......	......
	3,716	D. 7.1	64	8	......	1.112	1.184	1.202	1.234	1.180	1.244	1.246	1.124	1.114	1.006	0.895	......	......	......	......	......
	3,917	......	52	8	......	1.136	0.956	0.911	1.084	1.038	0.946	0,885	0.837	0.706	......	......	......	......	......	......	......
	4,109	0	45	7	......	0.977	0.800	0.914	0.904	0.858	0.737	0.685	0.432	......	......	......	......	......	......	......	......
June 26	4,364	D. 4.9	28	7	......	0.691	0.681	0.671	0.638	......	......	......	......	......	......	......	......	......	......	......	......
	4,545	......	17	15	......	0.448	0.430	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	126	D. 10.0	3	13	......	(1.5) 0.721	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	296	......	4.5	14	......	(2) 0.711	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	422	......	4.75	15	......	(3) 0.657	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	568	......	12	7	......	0.685	(8) 0.681	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	778	D. 11.2	19.5	10	......	0.957	0.884	0.880	......	......	......	......	......	......	......	......	......	......	......	......	......
	970	......	22	8	......	1.215	1.100	1.062	0.984	......	......	......	......	......	......	......	......	......	......	......	......
	1,172	......	28	7	......	1.538	1.493	1.366	1.317	1.038	......	......	......	......	......	......	......	......	......	......	......
	1,370	D. 1.2	33	6	......	1.659	1.669	1.522	1.600	1.417	0.995	......	......	......	......	......	......	......	......	......	......
	1.620	D. 15.6	60	6	......	1.735	1.582	1.597	1.469	1.545	1.515	1.486	1.354	1.266	1.150	1.220	......	......	......	......	......
June 29	1,806	D. 5.6	78	5	......	1.723	1.677	1.663	1.605	1.623	1.688	1.700	1.668	1.521	1.364	1.389	1.478	1.445	1.218	(74) 1.094	......
	2,014	......	85	4	......	1.717	1.622	......	1.575	......	1.575	1.	1.522	......	1.491	......	1.417	......	1.357	......	1.154
	2,150	D. 5.7	80	4	......	1.710	1.623	1.564	1.556	1.584	1.463	1.550	1.552	1.507	1.515	1.410	1.323	......	......	......	......
	2,335	......	75	5	......	1.700	1.720	1.681	1.627	1.526	1.500	1.571	1.509	1.415	1.390	1.380	1.289	1.178	1.053	......	......
	2,549	D. 7.4	67	4	......	1.575	1.580	......	1.562	......	1.571	......	1.483	......	1.326	......	1.138	......	......	......	......
June 30	2,776	0	67	6	......	1.575	1.545	1.507	1.530	1.552	1.526	1.493	1.445	1.414	1.311	1.129	0.989	......	......	......	......
	2,998	......	66	6	......	1.663	1.582	1.438	1.400	1.369	1.349	1.349	1.332	1.140	1.125	1.010	0.889	......	......	......	......
	3,187	D 16.6	68	5	......	1.636	1.500	......	1.519	......	1.309	......	1.340	......	1.242	......	0.907	0.887	......	......	......
	3,311	0	69	5	......	1.500	1.503	1.487	1.470	1.462	1.445	1.369	1.358	1.272	1.218	1.148	1.000	1.123	......	......	......
	3,531	0	66	5	......	1.562	1.344	1.351	1.394	1.373	1.394	1.254	1.346	1.264	1.218	1.171	0.895	......	......	......	......
		D. 19.4																			

July	1	3,708	D. 12.2	61	6	......	1.377	1.401	1.358	1.264	1.198	1.141	1.045	1.051	1.039	0.941	0.969	......	......	......	......	......
		3,872	D. 17.6	55	7	......	1.361	1.234	1.183	1.150	1.057	1.031	9.992	0.943	0.885	0.834	......	......	......	......	......	......
		4,055	D. 10.0	4.4	7	......	0.812	1.054	......	1.118	......	1.301	......	0.960	......	......	......	......	......	......	......	......
		4,252	D. 7.6	37	10	......	0.648	......	0.843	0.747	......	......	......	......	......	......	......	......	......	......	......	......
July	3	82	D. 12.4	3	12	......	(1, 5) 0.812	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		906	......	5.5	12	......	(2) 0.781	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		393	......	7	20	......	(3) 0.521	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		586	......	15	13	......	0.782	0.696	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		771	......	20	10	......	1.002	0.930	0.855	......	......	......	......	......	......	......	......	......	......	......	......	......
		982	......	25	6	......	1.511	1.618	1.421	1.154	......	......	......	......	......	......	......	......	......	......	......	......
		1,188	......	27	6	......	1.645	1.566	1.538	1.434	1.166	......	......	......	......	......	......	......	......	......	......	......
		1,444	D. 12.4	49	6	......	1.579	1.168	1.496	1.504	1.451	1.496	1.428	1.317	1.285	......	......	......	......	......	......	......
	3	1,662	D. 1.1	70	5	......	1.600	1.650	1.705	1.605	1.564	1.549	1.605	1.586	......	1.351	......	1.374	......	......	......	......
		1,768	D. 2.4	70	5	......	1.775	1.690	1.681	1.632	1.597	1.597	1.571	1.586	1.552	1.451	1.504	1.489	1.285	......	......	......
		1,955	0	79	5	......	1.690	1.609	1.645	1.623	1.564	1.564	1.519	1.564	1.545	1.465	1.511	1.465	1.417	1.383	1.128	......
July	8	2,116	U. 0.7	78	6	......	1.623	1.627	1.627	1.600	1.586	1.556	1.575	1.511	1.451	1.441	1.410	1.290	1.239	1.092	1.188	......
		2,297	U. 10.5	70	6	......	1.549	1.614	1.614	1.566	1.568	1.556	1.552	1.469	1.363	1.334	1.280	1.346	1.114	......	......	......
		2,460	......	67	6	......	1.526	1.627	1.575	1.568	1.725	1.700	1.349	1.309	1.434	1.472	1.144	1.134	......	......	......	......
		2,686	U. 6.0	64	6	......	1.519	1.489	1.556	1.511	1.575	1,571	1.476	1.351	1.583	1.261	1.180	0.901	......	......	......	......
July	9	4,443	U. 6.0	24	18	......	0.986	0.561	0.544	......	......	......	......	......	......	......	......	......	......	......	......	......
		4,326	......	42	11	......	0.753	0.898	......	0.953	......	0.890	0.747	......	......	......	......	......	......	......	......	......
		4,160	......	40	9	......	1.000	1.180	1.202	1.114	0.993	0.990	......	0.869	......	......	......	......	......	......	......	......
		3,840	U. 2.5	54	8	......	1.392	1.070	1.184	1.138	1.142	1.044	0.959	1.008	1,026	0.906	......	......	......	......	......	......
		3,678	0	60	7	......	1.489	1.333	1.326	1.377	1.272	1.340	1.360	1.246	1.210	1.215	1.036	......	......	......	......	......
July	10	2,908	0	63	6	......	1.575	1.586	1.538	1.530	1.519	1.472	1.389	1.394	1.329	1.212	......	......	......	......	......	......
		3,092	......	66	6	......	1.438	1.507	......	1.496	......	1.386	......	1.317	......	1.232	......	......	......	......	......	......
		3,252	......	66	6	......	1.406	1.526	......	1.493	......	1.424	......	1.403	......	1.431	1.366	1.369	......	......	......	......
		3,426	0	65	3	......	1.389	1.392	......	1.472	......	1.417	......	1.340	......	1.329	1.241	1.026	......	......	......	......
		300	......	3.5	13	......	(1, 5) 0.725	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		488	......	8.5	21	......	(4) 0.504	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		676	......	10	11	(1, 5) 0.914	0.765	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		886	0	21	8	(1) 1.212	1.267	1.148	0.939	......	......	......	......	......	......	......	......	......	......	......	......	......
		1,070	......	24	5	(1) 1.677	1.618	1.605	1.372	1.051	......	......	......	......	......	......	......	......	......	......	......	......
		1,275	D. 6.6	27	6	(1) 1.834	1.720	1.586	1.392	1.295	1.116	......	......	......	......	......	......	......	......	......	......	......
July	11	1,508	D. 7.2	45	5	(1) 1.839	1.775	1.775	1.730	1.672	1.645	1.571	1.632	1.351	1.486	......	......	......	......	......	......	......
		1,805	D. 11.5	73	4	(1) 1.790	1.828	1.796	1.690	1.740	1.705	1.636	1.564	1.476	1.472	1.641	1.568	1.369	1.149	......	......	......
July	13	2,040	D. 5.9	75	5	(1) 1.740	1.681	1.597	1.600	1.564	1.571	1.496	1.511	1.504	1.507	1.500	1.462	1.410	1.300	1.152	......	......
		2,269	......	71	6	(1) 1.839	1.695	1.641	1.614	1.564	1.597	1.530	1.504	1.469	1.476	1.504	1.489	1.543	1.162	(m) 1.202	......	......

TABLE A.—*Daily observations for velocity of current in the St. Lawrence River*, 1838—Continued.

VERTICAL.

Date.	Distance from base.	Wind in direction of river.	Depth of river.	Mean time run in minutes.	Observed velocity of river at the following depths:																
					0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
	2,410	D. 10.8	67	6	(1) 1.890	1.663	1.636	1.560	1.560	1.549	1.526	1.511	1.486	1.414	1,275	1.222	1.148	1.148	......	......	......
	2,605	......	63	6	(1) 1.785	1.755	1.534	1.504	1.351	1.472	1.417	1.314	1.360	1.239	1,132	0.952	......	......	......	......	......
	2,797	D. 14.0	64	6	......	1.600	1.586	......	1.479	......	1.366	......	1.380	......	1.261	......	0.990	......	......	......	......
July 14	2,973	D. 6.6	63	6	(1) 1.624	1.568	1.445	1.522	1.493	1.496	1.437	1.414	1.288	1.386	1.237	0.983	1.014	......	......	......	......
	3,180	......	66	7	(1) 1.632	1.568	1.530	1,507	1.448	1.438	1.343	1.397	1.326	1.314	1.176	1.116	0.937	0.933	......	......	......
.	3,328	D. 7.7	64	6	(1) 1.806	1.534	1.534	1.504	1.476	1.441	1.428	1.306	1.311	1.146	1.174	1.254	0.927	......	......	......	......
	3,512	D. 11.0	64	7	(1) 1.600	1.590	1.334	1.357	1.285	1.241	1.251	1.104	1.168	1.082	1.014	0.928	1.021	......	......	......	......
July 15	3,603	D. 8.8 D. 7.9	61	6	(1) 1.530	1,496	1.438	1.357	1.386	1.372	1.366	1.298	1.170	1.244	1.112	1.065	......	......	......	......	......
	3,800	D. 5.0	55	5	(1) 1.564	1.374	1.275	1.239	1.122	1.095	1.013	1.033	1.016	0.936	1.026	(54) 1.000	......	......	......	......	......
	3,950	D. 13.2	48	7	(1) 1.272	1.337	1.241	1.194	1.170	1.150	1.098	1.056	0 842	0.948	......	......	......	......	......	......	......
	4,100	0	44	7	......	1.118	1.178	1.082	1.090	1.014	1.946	0.912	0.879	......	......	......	......	......	......	......	......
	4,273	0	36	8	0.606	0.636	0.725	0.781	0.589	......	......	......	......	......	......	......	......	......	......	......	......
July 20	338	U. 6.1	5.5	20	(0.5) 0.527	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	537	......	10.5	9	......	0.300	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	717	......	17	21	......	0.592	0.300	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	916	......	21	12	(2) 0.800	0.920	0.904	0.785	(10) 0.674	......	......	......	......	......	......	......	......	......	......	......	......
	1,157	U. 11.9	25	7	(2) 1.146	1,184	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
July 21	1,206	0	24	6	(2) 1.451	1.369	1.340	1.340	1.168	......	......	......	......	......	......	......	......	......	......	......	......
	1,400	......	31	6	(2) 1.605	1.560	1.564	1.542	1,458	1.386	1.070	......	......	......	......	......	......	......	......	......	......
	1,146	......	65	5	(2) 1.800	1.740	1.650	1.597	1.605	1.726	1.632	1.605	1.570	1.522	1.641	1.507	1.455	......	......	......	......
	1,906	D. 9.9	73	5	......	1.730	1.668	......	1.593	......	1.645	......	1.564	......	1.431	......	1.424	......	1.306	......	......

July	22	2,011	U. 5.5	84	5		1.564	1.534	1.579	1.632	1.623	1.618	1.686	1.636	1.530	1.542	1.579	1.575	1.519	1.507	1.349	1.251
		2,398		66	5		1.593	1.618	1.618	1.515	1.534	1.605	1.493	1.579	1.519	1.504	1.263	1.372	1.244			
		2,428	U. 4.6	67	5		1.560	1.597	1.745													
		2,618		64	6		1.654	1.695	1.663	1.745	1.614	1.549	1.564	1.526	1.582	1.400	1.434	1.400	1.021			
		2,730	U. 4.2	63	6		1.534	1.522	1.681	1.650	1.654	1.545	1.560	1.564	1.493	1.400	1.314	1.268	(a) 1.008			
July	23	2,906	U. 3.0	57	6		1.542	1.472	1.496	1.556	1.597	1.618	1.549	1.542	1.383	1.357	1.259					
		3,002	U. 0.7	61	6		1.329	1.323	1.334	1.406	1.483	1.472	1.421	1.469	1.472	1.326	1.309	1.246				
July	24	3,314	0	66	6		1.489	1.522	1.496	1.462	1.383	1.351	1.354	1.349	1.369	1.217	1.237	1.154				
		3,478		63	6		1.424	1.491	1.414	1.416	1.410	1.403	1.380	1.346	1.357	1.266	1.074	1.120				
		3,609	D. 1.4	64	6		1.377	1.394	1.394	1.400	1.354	1.354	1.334	1.329	1.224	1.241	1.156	1.070				
		3,718	D. 8.4	58	6		1.249	1.349	1.354	1.274	1.317	1.303	1.277	1.277	1.239							
July	25	3,754	0	56	6		1.403	1.323	1.288	1.283	1.263	1.295	1.293	1.249	1.239	1.164						
				45	7		1.202	1.198		1.160		1.052		1.029								
		4,140		43	8		1.079	1.152		1.178		0.978		0.963								
		4,320	U. 2.5	36	7		0.604	0.698		0.781		0.749										
July	28	207	D. 0.7	4	17		(2) 0.588															
		290		4	17		(2) 0.605															
		490		8	26		(4) 0.455															
		684		15.5	16		0.612	0.567														
		901		20	11		0.907	0.868	0.784													
		1,094	D. 12.4	24	7		1.194	1.650	1.263	1.102												
		1,311	D. 10.0	28	6		1.504	1.605	1.534	1.458	1.170											
		1,554		48	5		1.745	1.659	1.575	1,586	1.545	1,465	1.428	1.326	1.298							
		1,731		70	5		1.597	1.605	1.507	1.575	1.659	1.500	1.542	1.609	1.489	1.421	1.417	1.346	1.354	(a) 1.140		
		1,916	D. 6.6	78	5		1.627	1.618	1.681	1.860	1.534	1.600	1.618	1.480	1.575	1.597	1.493	1.538	1.538	1.392	1.458	
July	29	2,121	0	78	5		1.609	1.519	3.476	1.511	1.545	1.614	1.511	1.479	1.455	1.438	1.424	1.389	1.511	1.507	1.259	
		2,303	0	70	5		1.522	1.515	1.579	1.568	1.511	1.549	1.530	1.519	1.507	1.472	1.406	1.366	1.229			
July	31	101	D. 12.6	2	12		(1) 0.786															
		271		4	12		(2) 0.812															
		2,492	D. 5.0	68	6		1.677	1.600	1.568	1.538	1.545	1.469	1.448	1.428	1.354	1.295	1.241	1.118	1.003			
		2,694	D. 5.4	66	6		1.677	1.650	1.545	1.526	1.511	1.493	1.489	1.351	1.397	1.277	1.144	1.120				
Aug.	3	2,910	U. 0	66	6		1.575	1.575	1.560	1.522	1.472	1.469	1.500	1.400	1.346	1.331	1.320	1.142				
		3,094		64	6		1.605	1.556	1.575	1.504	1.458	1.394	1.545	1.394	1.300	1.251	1.212	0.994				
		3,260	0	64	6		1.627	1.552	1.552	1.496	1.476	1.421	1.377	1.406		1.343		1.118				
		3,470		64	6		1.455	1.414	1.431	1.410	1.428	1.428	1.389	1.377	1.298	1.239	1.138	1.008				
		3,630		62	6		1.290	1.298	1.326	1.259	1.389	1.337	1.337	1.295	1.270	1.270	1.190					
		3,875	0	54	7		1.180	1.261	1.261	1.200	1.212	1.128	1.146	1.130	1.068	0.899						
Aug.	4	4,120	U. 5.1	44	9		1.215	1.196	1.166	1.049	1.016	0.940	0.801	0.823								
		4,400		30	11		0.847	0.853	0.830	0.807	0.808											
		1,395	U. 3.5	30	5		1.618	1.654	1.618	1.582	1.479	1.283										
		1,212		26	6		1.568	1.455	1.331	1.295												
		1,030		21	8		1.156	1.112	1.059	0.928												
		808	U. 4.2	19	15		0.763	0.666	0.640													
Aug.	5	293	U. 6.1	4	22		(2) 0.481															

TABLE A.—*Daily observations for velocity of current of the St. Lawrence River*, 1868.

VERTICAL.

Date.	Distance from base.	Wind in direction of river.	Depth of river.	Mean time run in minutes.	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
					Observed velocity of the river at the following depths:																
	490		8	32		(4) 0.380															
	685		15	17		0.608	0.593	(10) 0.567													
	933	U. 7.0	19	14		0.933	1.036	0.644													
	1,176		24	8		1.695	1.445	1.343	1.200												
	1,404		31	7		1.645	1.465	1.469	1.410	1.051	1.051										
	1,672	U. 1.9	61	5		1.668	1.725	1.730	1.690	1.641	1.614	1.568	1.590	1.540	1.545	1.538	1.500				
Aug. 6	1,810	U. 0.9	71	5		1.632	1.672	1.681	1.681	1.672	1.695	1.654	1.614	1.623	1.586	1.614	1.465	1.434	1.334		
Aug. 10	1,277	U. 0	24	5		1.511	1.564	1.515	1.522												
	1,508		43	5		1.672	1.590	1.593	1.515	1.519	1.560	1.410	1.207								
	1,721		66	5		1.534	1.455	1.534	1.495	1.479	1.479	1.462	1.500	1.469	1.423	1.465	1.241				
	1,910	D. 1.5	73.5	6		1.700	1.632	1.605	1.545	1.542	1.489	1.445	1.458	1.421	1.451	1.403	1.400	1.363	1.229		
	2,132		75	6		1.659	1.568	1.380	1.522	1.465	1.403	1.406	1.363	1.354	1.306	1.263	1.200	1.182	1.217		
	2,333	D. 8.3	67	6		1.545	1.542		1.519		1.515		1.436		1.402		1.270	1.170			
Aug. 11	2,545	0	62	7		1.575	1.532	1.500	1.493	1.455	1.434	1.366	1.283	1.293	1.168	1.198	1.065				
Aug. 13	2,719	D. 10.0	57	8		1.617	1.607	1.586	1.589	1.546	1.515	1.464	1.441	1.355	1.252	1.083					
	2,915		60	10			1.556		1.505		1.439		1.405		1.318						
	3,053	0	60	5		1.447	1.561	1.556	1.525	1.510	1.497	1.497	1.510	1.462	1.392	1.320	1.166				
	3,253		63	5		1.285	1.341	1.351	1.402	1.341	1.418	1.413	1.402	1.382	1.351	1.249	1.172				
	3,465	0	60	6			1.279		1.373		1.360		1.313		1.223						
Aug. 14	3,680	D. 8.6	58	10		1.413	1.395	1.338	1.313	1.259	1.193	1.193	1.175	1.097	1.006	0.768					
	3,901	D. 1.8	48	10		1.318	1.259	1.313	1.198	1.113	0.968	0.945	0.836	0.683							
Aug. 15	4,152	D. 18.0	40	10		1.259	1.213	1.094	1.110	0.971	0.816	0.783									
Aug. 17	752		16	5		1.102	0.800														
	885	U. 1.4	20	5		1.057	0.945	0.678													
Aug. 18	1,157		24	10		1.364	1.313	1.307	1.088												
	1,375		31	10		1.665	1.652	1.587	1.447	1.313	(20) 1.070										
	1,547		49	10		1.677	1.698	1.635	1.589												
	1,800	D. 9.2	67	10		1.790	1.846	1.805	1.758	1.632	1.642										
Aug. 20	1,702	U. 3.2	64	10		1.652	1.670	1.543	1.462	1.564	1.630	1.500	1.551	1.580	1.400	1.450	1.367				
	1,900		76	5		1.582	1.508	1.582	1.531	1.488	1.488		1.497		1.341		1.275		1.188		

	2,097		72	10		1.582	1.566	1.561	1.587	1.551	1.561	1.574	1.533	1.551	1.538	1.462	1.442	1.323	1.333		
	2,300		70	5		1.431	1.535	1.535	1.497	1.505	1.397	1.377	1.392	1.362	1.447	1.305	1.088				
Aug. 21	2,503	U. 3.6	65	10		1.520	1.510	1.528	1.525	1.481	1.491	1.423	1.390	1.400	1.351	1.277	1.156				
	2,698		64	8		1.598	1.582	1.550	1.515	1.493	1.472	1.426	1.354	1.300	1.280	1.062	1.153				
	2,884	U. 3.0	65	10		1.587	1.569	1.535	1.505	1.488	1.467	1.431	1.392	1.367	1.313	1.202	1.088				
	3,065		64	10		1.517	1.478	1.413	1.395	1.387	1.343	1.331	1.297	1.251	1.207	1.190	1.116				
Aug. 22	3,290		64	8		1.569	1.476	1.546	1.470	1.385	1.325	1.292	1.221	1.153	1.070	1.025	0.937				
	3,515		65	5		1.392	1.351	1.397	1.387	1.387		1.290	1.228	1.182	1.134	0.929	0.857				
	3,763	0	58	10		1.295	1.221	1.216	1.110	1.228	1.318	1.180	1.124	1.067	1.083	0.826					
	3,945	D. 1.5	52	10		1.182	1.180	1.085	1.075	1.083	1.014	0.976	0.877	0.793							
Aug. 24	4,126	D. 9.5	42	10		1.302	1.216	1.097	1.020	0.892	1.814										
	4,343		32	10																	
	1,087		25	10		1.251	1.118	1.017	0.857												
	1,296	D. 14.4	26	10		1.512	1.426	1.436	1.267	1.022											
Aug. 25	1,476	D. 3.1	48	5		1.483	1.585	1.617	1.561	1.520	1.483	1.295	1.341	1.207							
	1,690		72	10		1.732	1.672	1.652	1.632	1.642	1.622	1.587	1.554	1.522	1.510	1.462	1.423	1.300	1.177		
	1,892	D. 3.0	81	10		1.737	1.760	1.687	1.655	1.577	1.551	1.587	1.462	1.598	1.455	1.483	1.590	1.382			
		(D. 9.0)																			
Aug. 26	2,091	D. 8.9	80	8		1.585	1.505	1.493	1.503	1.497	1.507	1.457	1.408	1.364	1.385	1.313	1.200	1.320	1.244	1.054	
	2,312		72	5		1.571	1.488	1.357	1.325	1.493	1.467	1.392	1.350	1.213	1.113						
	2,427	D. 7.8	67	5		1.657	1.642	1.598	1.556	1.515	1.525	1.500	1.505	1.402	1.382	1.285	1.233				
		(U. 9.4)																			
Aug. 28	310	D. 12.0	4	10																	
	531			10																	
	697			10																	
	908		10	10		0.805															
Aug. 31	1,157	0	24	6	(a) 1.337	1.351	1.314	1.098													
	1,354		28	6	1.560	1.428	1.410	1.349	1.136												
	1,518		45	6	1.597	1.575	1.496	1.519	1.445	1.438	1.275	1.128									
	1,690		68	6																	
	1,822		68	6	(a) 1.549	1.556	1.500	1.524	1.522	1.476	1.229	1.372	1.421	1.451	1.434	1.357	1.275				
Sept. 3	1,954	U. 6.0	78	6		1.515	1.569	1.500	1.538	1.515	1.538	1.357	1.357	1.309	1.234	1.241	1.397	1.357	1.400	1.227	
	2,115	U. 0.5	80	5		1.597	1.647	1.650	1.632	1.668	1.593	1.668	1.609	1.600	1.511	1.511	1.479	1.307	1.326	1.306	1.142
	2,316	0	72	6		1.375	1.545	1.549	1.571	1.571	1.568	1.483	1.285	1.414	1.212	1.290	1.403	1.239			
	2,380	0	66	6		1.560	1.383	1.560	1.542	1.522	1.465	1.406	1.380	1.428	1.369	1.229	1.104				
Sept. 4	2,720		64	6		1.582	1.493	1.530	1.455	1.500	1.445	1.458	1.434	1.417	1.383	1.259	1.168				
	2,872	D. 2.1	64	5		1.506	1.538	1.524	1.462	1.515	1.424	1.462	1.414	1.377	1.351	1.253	1.110				
	3,060		63	3		1.568	1.479	1.479	1.515	1.479	1.545	1.403	1.386	1.340	1.270	1.098	0.948				
	3,254		63	6		1.472	1.366	1.441	1.472	1.431	1.406	1.400	1.400	1.283	1.285	1.116	1.054				
	3,466		64	6		1.410	1.400		1.346		1.317		1.317		1.311		1.102				
	3,691		60	8			1.320		1.242		1.248		1.180		1.112						
Sept. 6	4,299	0	28	10		0.899	0.716	0.463													
	4,100	0	43	7		1.287	1.224	1.196	1.059	1.081	0.939	0.858	0.787								
	3,894		48	7		1.205	1.232	1.222	1.246	1.150	1.156	1.065	0.971	0.845							
	275		5.5	8		(a) 0.612															
	467		6	14		(d) 0.430															
	672		15	11		0.604	0.529														
	886		21	7		1.016	0.973	0.808													

TABLE A.—*Daily observations for velocity of current of the St. Lawrence River*, 1868—Continued.

VERTICAL.

Date.	Distance from base.	Wind in direction of river.	Depth of river.	Mean time run in minutes.	Observed velocity of the river at the following depths:																
					0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
	1,125	U. 0.7	26	6	......	1.479	1.389	1.369	1.074	......	......	......	......	......	......	......	......	......	......	......	......
	1,311	......	29	6	......	1.659	1.609	1.556	1.430	1.158	......	......	......	......	......	......	......	......	......	......	......
	1,516	0	48	5	......	1.790	1.686	1.750	1.623	1.623	1.549	1 590	1.472	1.254	......	......	......	......	......	......	......
Sept. 10	1,745	0	70	5	......	1.564	1.549	1.568	1.578	1.593	1.586	1.582	1.568	1.556	1.5[illegible]0	1.571	1.465	1.340	......	......	......
	1,933	0	78	5	......	1.597	1.552	1.534	1.534	1.600	1.542	1.534	1.406	1.479	1.428	1.462	1.357	1.377	1.217	1.441	......
	2,097	......	80	5	......	1.715	1.632	1.677	1.526	1.609	1.560	1.549	1.486	1.522	1.663	1.483	1.414	1.410	1.386	1.270	......
	2,305	......	72	5	......	1.636	1.597	1.609	1.564	1.579	1.597	1.560	1.493	1.493	1.479	1.403	1.354	1.283	1.323	......	......
	2,457	......	67	5	......	1.627	1.618	1.560	1.609	1.575	1.540	1.571	1.500	1.465	1.392	1.386	1.182	1.190	......	......	......
Sept. 11	2,666	D. 7.8	66	6	......	1.552	1.542	1.488	1.493	1.441	1.441	1.507	1.458	1.389	1.343	1.320	1.194	......	......	......	......
	2,870	D. 7.8	65	6	......	1.568	1.530	1.486	1.530	1.458	1.451	1.462	1.363	1.277	1.152	1.132	1.118	......	......	......	......
	3,101	D. 5.5	65	6	......	1.489	1.283	1.383	1.445	1.38[illegible]	1.369	1.366	1.351	1.295	1.311	1.182	1.124	......	......	......	......
	3,298	......	64	7	......	1.351	1.457	1.445	1.434	1.329	1.361	1.237	1.360	1.178	1.266	1.146	1.056	......	......	......	......
	3,522	......	64	7	......	1.239	1.389	......	1.351	......	1.386	......	1.290	......	1.266	......	0.964	......	......	......	......
Sept. 12	3,750	U. 3.6	60	8	......	1.340	1.234	1.186	1.120	1.128	1.074	1.062	1.033	0.917	0.931	0.911	......	......	......	......	......
	3,890	......	50	9	......	1.144	1.136	1.057	1.006	0.980	0.964	0.890	0.834	......	......	......	......	......	......	......	......
	4,083	U. 5.0	43	10	......	0.973	1.112	1.019	0.934	1.016	0.940	0.883	0.793	......	......	......	......	......	......	......	......
	4,274	......	30	14	......	0.717	0.635	0.755	......	......	......	......	......	......	......	......	......	......	......	......	......
	4,454	U. 6.0	15	14	......	0.280	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

TABLE A.—*Daily observations for velocity of current in the St. Lawrence River, 1868.*

HORIZONTAL.

Date.	Depth of observation.	Wind in direction of river.	Depth of river.	Mean time run in minutes.	Velocity. Distance from base.																
					803	952	1165	1348	1567	1813	2018	2168	2288	2450	2640	2767	3020	3158	3271	3478	3588
June 18	10	D. 8.4	....	6	0.868	1.153	1.504	1.672	1.700	1.677	1.690	1.636	1.720	1.677	1.618	1.636	1.564	1.511	1.406	1.369	1.389
					3.655	3.808	3.948	4.112	4.235	4.394	......	......	......	......	......	......	......	......	......	......	......
					1.277	1.202	1.212	1.120	0.844	0.803	......	......	......	......	......	......	......	......	......	......	......
July 12	20	D. 10.7	....	12	1.546	1.796	1.987	2.168	2.370	2.496	2.657	2.848	3.032	3.206	3.402	3.600	3.756	3.930	4.151	4.307	......
					1.624	1.550	1.545	1.570	1.540	1.483	1.462	1.393	1.455	1.453	1.372	1.326	1.200	1.076	0.910	0.670	......
July 27	30	D. 4.5	....	12	1.567	1.798	1.997	2.168	2.377	2.566	2.760	2.998	3.040	3.270	3.540	3.760	3.940	4.140	......	......	......
					1.577	1.549	1.599	1.545	1.515	1.476	1.451	1.406	1.449	1.405	1.347	1.205	1.089	0.957	......	......	......
Sept. 14	......	U. 1.0	...	....	1.510	1.694	1.904	2.103	2.297	2.498	2.714	2.889	3.078	3.266	3.480	3.696	3.921	......	......	......	......
	10	....	....	....	1.552	1.593	1.556	1.627	1.556	1.542	1.556	1.552	1.552	1.417	1.290	1.186	1.148	......	......	......	......
	20	....	....	....	1.571	1.549	1.614	1.504	1.564	1.504	1.515	1.441	1.438	1.451	1.331	1.222	1.035	......	......	......	......
	30	....	....	....	1.519	1.582	1.511	1.493	1.476	1.526	1.421	1.431	1.394	1.394	1.403	1.239	1.059	......	......	......	......

TABLE B.—*Sub-surface velocities in nearly the same depth of water, St. Clair River*, 1868.

VERTICAL.

Date.	Distance from base.	Wind in direction of river.	Depth of river.	Mean time run, in minutes.	Observed velocity of river at the following depths: 0	5	10	15	20	25	30	35	40	45
June 29	844	U. 8.0	55	10	3.777	3.900	3.819	3.762	3.691	3.641	3.600	3.353	3.094	2.830
June 29	1,010	U. 8.0	53	10	....	4.244	4.264	4.148	4.045	4.040	3.814	3.718	3.521	3.236
June 30	1,155	U. 7.5	53	10	....	4.032	3.832	3.733	3.620	3.426	3.308	3.167	2.884	3.455
July 18	802	U. 3.0	53	5	3.978	4.165	4.089	4.045	3.906	3.819	3.682	3.465	3.301	2.728
July 20	972	U. 2.0	54	7	....	4.200	4.239	4.156	4.133	3.846	3.773	3.588	3.580	3.318
July 30	929	U. 5.2	54	5	3.768	4.248	4.059	3.942	4.029	4.017	....	....	....	....
July 30	953	U. 3.2	54	10	4.968	4.038	4.018	3.836	3.699	3.819	3.632	3.601	3.418	2.936
August 6	958	U. 5.0	54	5	4.098	4.112	4.106	4.123	3.972	3.659	3.670	3.601	3.471	3.270
August 14	806	D. 2.4	53	5	....	4.165	3.998	3.972	3.957	3.786	3.486	3.442	3.341	3.239
August 14	901	U. 0.8	54	5	....	3.996	4.022	3.921	3.894	3.709	3.703	3.570	3.375	3.211
August 15	1,003	U. 0.5	53	5	3.298	4.101	4.031	3.896	3.814	3.796	3.572	3.531	3.241	2.643
Sums	....	....	....	....	22.887	45.201	44.477	43.534	42.760	41.558	36.240	35.036	33.226	29.866
Means	....	U. 3.7	....	....	3.814	4.109	4.043	3.958	3.887	3.778	3.624	3.503	3.323	2.986
July 28	779	D. 8.5	52	5	....	4.226	4.075	3.970	3.955	3.896	3.773	3.659	3.244	3.208
August 6	1,089	U. 11.3	51	5	....	3.940	3.914	3.871	3.821	3.580	3.536	3.580	3.075	2.457
August 15	1,100	U. 0.8	50	5	....	3.794	3.727	3.657	3.719	3.375	3.331	3.274	2.865	2.431
September 17	1,065	D. 3.1	50	3	....	4.067	3.806	3.936	3.849	3.704	3.297	3.122	2.972	2.907
July 20	955	U. 4.5	52	10	....	4.127	4.020	3.998	3.828	3.814	3.632	3.603	3.216	3.170
July 21	1,093	D. 5.0	51	10	....	4.135	3.873	3.813	3.821	3.544	3.465	3.212	3.168	2.954
Sums	....	....	....	....	....	24.289	23.415	23.245	22.993	21.913	21.034	20.450	18.540	17.127
Means	....	00,0	....	....	....	4.048	3.903	3.874	3.832	3.652	3.506	3.408	3.090	2.854
July 1	1,294	U. 6.8	48	10	2.880	3.541	3.515	3.309	3.185	3.169	2.929	2.565	2.159	....
July 1	1,294	U. 3.5	48	6	....	3.228	3.524	3.429	3.216	2.978	2.946	2.643	2.225	....
July 9	604	D. 10.0	48	5	....	4.331	4.373	4.196	4.026	3.409	....	....	....	....
July 28	689	D. 8.9	47	5	....	4.266	4.278	4.215	4.064	3.957	3.586	3.575	....	....
July 28	690	D. 2.5	47	5	4.168	4.364	4.121	3.942	3.703	3.645	3.624	3.283	3.285	(42) 3.109
August 7	1,227	U. 12.5	48	5	....	3.601	3.581	3.178	3.365	3.357	3.041	2.814	2.391	....
August 17	1,151	U. 1.5	48	5	....	3.978	3.798	3.665	3.505	3.308	3.324	3.301	2.691	(44) 2.114

September 4	1,044	U.	0.6	49	14	....	4.119	4.181	4.179	3.851	3.694	3.716	3.577	3.343	(43) 3.219
September 11	1,042	D.	8.4	49	5	3.794	4.129	4.086	4.137	4.018	3.819	3.948	3.750	3.365	(43) 3.331
September 11	1,042	D.	8.4	49	5	3.898	4.076	4.193	4.026	3.929	3.886	3.749	3.665	3.427	....
September 14	735	U.	1.5	49	3	....	4.108	3.913	3.854	3.828	3.686	3.635	3.331	3.207	(43) 2.137
June 27	561	D.	4.8	45	10	3.875	4.464	4.396	4.137	3.978	3.985	3.731	3.612	2.578	....
June 30	1,357	U.	8.2	45	10	2.521	3.456	3.338	3.159	3.101	2.968	2.879	2.572	2.107	....
July 9	512	D.	8.2	45	10	3.998	4.470	4.524	4.418	4.238	3.948	3.900	3.506	2.860	....
July 16	724	D.	9.0	46	10	4.295	4.471	4.381	4.074	4.105	3.998	3.811	3.786	3.270	....
July 16	729	D.	7.2	46	10	4.144	4.501	4.227	4.221	4.106	4.035	3.771	....	....	....
July 21	1,202	D.	7.5	46	5	....	3.845	3.778	3.732	3.655	3.511	3.247	3.178	2.985	....
July 22	1,211	D.	8.3	45	6	3.707	3.944	3.871	3.825	3.491	3.421	3.288	3.057	2.920	2.588
July 24	1,268	D.	16.0	45	5	3.429	3.732	3.858	3.626	3.598	3.473	3.301	2.725	2.498	2.374
July 27	565	U.	2.4	44	5	....	4.492	4.267	4.297	4.270	3.998	3.725	3.511	2.616	....
August 7	1,241	U.	13.3	45	5	....	3.498	3.313	3.341	3.116	2.968	2.728	2.710	1.847	....
August 11	1,349	D.	5.0	44	5	....	3.481	3.378	3.298	3.229	3.049	2.704	2.494	1.988	....
August 14	596	D.	2.1	46	5	3.786	4.110	4.131	3.998	3.901	3.721	3.549	3.198	2.397	....
August 17	1,273	U.	5.7	46	5	....	3.693	3.672	3.570	3.511	3.255	3.134	3.078	1.955	....
August 17	1,310	U.	8.0	45	5	3.187	3.649	3.608	3.588	3.435	3.305	3.063	2.756	1.936	....
August 22	529	D.	0.5	46	5	4.011	4.470	....	4.089	....	3.601	....	3.150	3.020	....
August 25	444	U.	5.7	46	5	3.750	4.215	4.166	4.081	4.053	3.925	3.711	3.278	2.940	....
September 1	395	D.	3.9	44	5	....	4.345	4.224	4.081	3.997	3.898	3.639	3.261	....	....
September 1	467	D.	8.0	44	5	....	4.334	4.259	4.080	4.032	3.787	3.717	3.482	2.632	....
September 10	1,240	U.	3.5	46	5	....	3.549	3.435	3.324	3.101	3.043	2.808	2.886	2.028	....
September 10	1,240	U.	3.5	46	5	....	....	3.642	3.435	3.365	3.191	3.151	2.761	....	....
September 12	1,249	U.	3.5	44	3	3.456	3.686	3.660	3.639	3.237	3.280	3.101	2.710	....	....
September 14	487	U.	5.0	45	3	3.370	4.057	4.026	3.930	3.871	3.798	3.498	2.972	2.730	....
September 17	458	U.	2.2	44	3	3.998	4.431	4.183	4.244	3.891	4.174	3.828	3,524	2.290	....
Sums	....		....	....	....	66.267	132.634	130.030	130.317	121.971	127.240	108.842	100.710	73.600	....
Means	....	D.	0.9	....	....	3.681	4.019	3.941	3.833	3.696	3.566	3.401	3.147	2.629	....
July 8	323	D.	10.0	41	10	3.980	4.443	3.976	3.890	3.806	3.439	3.114	2.598	....	....
July 9	372	D.	9.0	42	10	4.042	4.453	4.338	4.152	4.034	3.970	3.627	3.248	....	....
July 10	508	U.	0.7	43	10	4.005	4.518	4.379	4.204	4.060	3.890	....	....	....	....
July 22	1,367	D.	3.6	42	5	....	3.544	3.534	3.471	3.425	3.121	2.775	2.532	(38) 2,020	....
July 22	1,393	D.	7.3	41	5	....	3.462	3.388	3.226	3.080	3.057	2.471	2.241	....	....
July 27	392	D.	2.4	43	10	4.173	4.119	4.095	3.841	3.744	3.717	3.620	3.098	(38) 2.606	....
July 27	510	U.	1.6	43	5	4.212	4.536	4.420	4.168	4.076	4.089	3.860	3.551	(38) 3.125	....
August 13	397	D.	1.5	43	5	....	4.213	4.303	4.185	4.003	3.788	3.531	2.975	(38) 2.951	....
August 13	531	U.	0.8	43	5	....	4.448	4.306	4.165	4.054	3.870	3.727	3.351	(38) 2.851	....
August 22	1,411	U.	0.7	42	5	3.021	3.049	3.124	2.963	2.883	2.663	2.233	1.666	....	....

TABLE B.—*Sub-surface velocities in nearly the same depth of water, &c.*—Continued.

VERTICAL.

Date.	Distance from base.	Wind in direction of river.		Depth of river.	Mean time run, in minutes.	Observed velocity of river at the following depths: 0	5	10	15	20	25	30	35	40	45
August 22	1,379	D.	4.0	42	5	......	3.378	3.256	3.188	2.907	2.820	2.376	2.347	(38) 1.691	......
August 25	378	U.	5.7	43	5	3.078	4.135	3.858	3.845	3.649	3.452	3.285	2.775	......	......
August 26	547	D.	14.2	43	5	......	4.381	4.314	4.215	4.110	3.896	3.693	3.263	(38) 3.255	......
September 2	1,309	U.	0.3	43	16	......	3.228	3.216	3.101	2.858	2.824	2.804	......	......	......
September 10	378	U.	3.2	43	2	3.687	4.067	3.825	3.935	3.709	3.678	3.198	2.808	......	......
Sums	......	......		......	......	30.798	59.974	58.332	56.549	54.398	52.274	44.314	36.453	18.501	......
Means	......	D.	2.6	......	......	3.847	3.998	3.889	3.770	3.627	3.485	3.165	2.804	2.643	......
July 2	1,477	U.	4.5	38	10	2.868	2.914	2.828	2.471	2.513	2.182	1.825	(32) 1.621	......	......
July 22	1,458	D.	12.4	38	5	......	3.128	3.078	2.901	2.670	1.886	1.720	(33) 1.501	......	......
July 25	322	D.	2.4	38	5	3.883	4.126	3.962	3.894	3.572	3.355	3.175	(32) 2.949	......	......
August 5	1,349	U.	2.6	40	5	3.541	3.572	3.544	3.365	3.349	3.001	2.970	(32) 2.796	......	......
August 11	1,453	D.	5.0	39	5	2.731	3.024	2.872	2.820	2.419	2.266	2.060	(32) 1.897	......	......
Sums	......	......		......	......	13.023	16.764	16.284	15.451	14.523	12.690	11.750	10.764	......	......
Means	......	D.	2.5	......	......	3.256	3.353	3.257	3.090	2.905	2.538	2.350	2.153	......	......
August 13	307	D.	1.2	37	5	2.959	3.766	3.518	3.452	3.370	3.216	2.912	......	......	......
August 14	1,508	U.	0.6	36	5	......	3.017	2.799	2.682	2.260	1.921	1.537	......	......	......
August 22	1,490	D.	6.2	35	5	2.543	2.868	2.807	2.643	2.307	1.913	1.618	......	......	......
Sums	......	......		......	......	5.502	9.651	9.124	8.877	7.937	7.050	6.067	......	......	......
Means	......	D.	2.3	......	......	2.751	3.217	3.041	2.926	2.646	2.350	2.022	......	......	......

July 2	1,639	U. 5.0	27	10	2.080	2.114	2.225	1.911	1.883	1.487	......	......	......	......
July 24	1,619	D. 18.0	20	5	......	2.701	2.710	2.604	2.225	2.051	......	......	......	......
August 11	1,453	D. 9.8	30	5	......	2.933	2.813	2.555	2.364	1.889	......	......	......	......
August 11	1,653	D. 9.8	29	5	......	2.581	2.279	2.200	2.072	1.548	......	......	......	......
September 2	1,542	U. 8.0	29	21	......	2.601	2.425	2.258	1.839	......	......	......	......	......
September 12	1,657	U. 5.7	28	4	......	2.046	1.889	1.992	1.899	1.340	......	......	......	......
July 8	218	D. 8.9	30	10	3.070	3.158	3.088	3.062	2.691	2.142	......	......	......	......
August 21	208	D. 10.6	27	5	......	3.068	2.845	2.710	2.638	......	......	......	......	......
August 25	254	U. 4.8	31	5	......	3.378	3.282	3.171	3.075	2.701	......	......	......	......
September 9	244	U. 8.5	30	3	......	3.093	2.916	2.846	2.626	2.307	......	......	......	......
Sums	......		...	...	5.150	27.673	26.572	25.309	23.312	15.465	......	......	......	......
Means	......	D. 0.7	...	...	2.575	2.767	2.657	2.531	2.331	1.933	......	......	......	......
June 27	184	D. 1.4	21	20	1.726	1.880	1.928	1,671	(18) 1.227	......	......	......	......	......
July 25	192	D. 6.2	23	5	2.736	2.793	2.738	2.246	(18) 2.091	......	......	......	......	......
August 13	198	U. 0.4	22	5	2.678	2.832	2.720	2.604	(18) 2.344	......	......	......	......	......
August 25	170	U. 4.8	19	5	1.645	1.895	1.813	1.422	......	......	......	......	......	......
August 17	1,711	U. 8.5	21	5	1.157	1.311	1.276	1.073	(18) 0.914	......	......	......	......	......
Sums	......		...	...	9.942	10.711	11.475	9.016	6.576	......	......	......	......	......
Means	......	U. 1.2	...	...	1.988	2.142	2.295	1.803	1.644	......	......	......	......	......

TABLE B.—*Sub-surface velocities in nearly the same depth of water, &c.*—Continued.

HORIZONTAL.

Date.	Depth of observations.	Wind in direction of river.	Mean time run in minutes.	Velocities at the following distances from base:							
July 7	....	D. 2.67	....	242	369	643	936	1,195	1,300	1,639	
	5		10	2.853	4.741	4.239	4.112	4.022	3.549	2.488	....
	10		10	3.217	4.406	3.994	4.235	3.783	3.470	2.452	....
July 29	....	U. 1.89	....	271	499	698	970	1,107	1,254	1,376	1,564
	15		5	3.596	4.102	4.270	3.927	3.845	3.639	3.024	2.238
	20		5	3.336	3.898	3.970	3.852	3.674	3.533	2.860	1.848
	25		5	3.117	3.917	3.755	3.768	3.494	3.403	2.688	1.590
August 10	....	D. 0.07	....	301	488	688	947	1,093	1,253	1,393	
	30		5	2.552	3.698	3.621	3.832	3.259	3.370	2.488	....
	35		5	....	3.524	3.480	3.585	3.301	2.805	1.921	....
	40		5	....	(38) 2.878	3.186	3.411	3.175	2.334	....	....
	45		5	....	....	(42) 2.886	....	2.731	....	....	....
August 12	....	D. 10.32	....	295	536	714	894	1,181	1,414		
	5		5	3.665	4.489	4.284	4.267	3.852	3.229	....	....
	10		5	3.682	4.497	4.289	4.303	3.690	3.217	....	....
	15		5	3.616	4.259	4.165	4.160	3.685	3.024	....	....
	20		5	3.172	4.221	3.026	3.957	3.631	2.900	....	....
August 24	....	U. 3.46	....	286	484	749	896	993	1,268	1,413	1,636
	25		5	3.036	3.883	3.713	3.768	3.819	3.293	2.659	1.770
	30		5	2.586	3.742	3.605	3.758	3.026	3.221	2.283	....
	35		5	....	3.347	3.357	3.501	3.565	2.840	1.562	....

August 26	....	D. 5.04	....	466	696	896	1,026	1,209	....	....	....
	40		5	([illegible]) 2.692	2.980	3.567	3.339	2.599	....	....	....
	45		5	....	(42) 2,904	3.447	2.946	(42) 2.040	....	....	....
	50		5	....	....	([illegible]) 2.840	(47) 2.886	....	....	....	....

TABLE B.—*Sub-surface velocities in nearly the same depth of water, Niagara River,* 1868.

VERTICAL.

Date.	Distance from base.	Wind in direction of river.	Depth of river.	Mean time run in minutes.	Observed velocity of river at the following depths: 1–2	5	10	15	20	25	30	35	40	45	50
July 11	616	U. 4.7	58	20	4.121	4.458	4.198	4.153	3.972	4.260	3.977	4.416	3.899	3.648	3.402
August 5	663	U. 5.8	60	40	....	4.212	4.116	4.220	4.009	3.599	3.506	3.402	3.381	3.207	3.002
Sums	....	....	...	...	4.121	8.670	8.314	8.373	7.981	7.859	7.383	7.818	7.280	6.855	6.404
Means	....	U. 5.2	...	...	4.121	4.335	4.157	4.186	3.990	3.930	3.691	3.909	3.640	3.427	3.202
July 22	180	D. 3.5	56	25	2.468	2.394	2.847	2.573	2.730	....	....	2.789	2.093	2.242	1.796
July 27	740	D. 3.3	57	30	4.769	4.374	4.677	4.304	4.680	4.412	4.119	3.969	3.655	3.286	2.850
July 29	860	D. 3.9	57	20	4.746	4.682	4.067	3.707	4.551	4.220	3.857	3.676	(w) 3.553	....	2.720
Sums	....	....	...	...	11.983	11.450	11.611	10.584	11.961	8.632	7.966	10.434	9.301	5.528	6.966
Means	....	D. 3.6	...	...	3.994	3.817	3.870	3.528	3.987	4.316	3.983	3.478	3.100	2.764	2.322
June 25	1,089	U. 6.0	53	10	3.889	4.022	4.774	4.470	3.844	3.760	3.710	3.660	3.807	....	....
June 26	1,009	U. 4.5	53	25	3.916	4.284	4.560	4.418	4.268	4.202	3.899	3.483	3.627	3.318	....
July 7	1,130	U. 7.8	53	23	4.339	4.124	4.239	4.144	4.256	4.134	3.875	3.657	3.137	2.806	2.781
August 4	926	0	54	30	....	3.388	3.845	3.815	3.952	3.867	3.627	3.349	2.888	2.866	2.563
August 31	904	0	54	40	3.944	3.627	3.820	3.585	3.431	3.234	3.073	3.148	2.659	2.370	....
September 4	1,128	D. 6.7	53	35	3.583	3.627	3.710	3.479	3.290	3.204	2.969	2.845	2.623	2.327	....
September 5	1,027	0	53	40	3.409	3.485	3.600	3.540	3.635	3.577	3.310	3.088	2.921	2.452	....
Sums	....	....	...	...	22.650	26.857	28.548	27.451	26.676	25.978	24.463	23.230	19.662	16.139	5.344
Means	....	U. 1.6	...	...	3.775	3.837	4.079	3.921	3.811	3.711	3.495	3.319	2.809	2.306	2.672
June 23	1,519	D. 8.0	50	30	....	3.943	3.828	3.863	3.567	3.264	3.447	3.447	3.373	2.850	....
June 30	1,552	D. 7.9	50	25	3.432	3.543	3.620	3.877	3.350	3.200	3.343	3.129	3.123	3.162	....
July 1	1,021	D. 4.5	48	30	....	3.455	3.445	2.859	2.683	3.053	3.150	2.734	2.698	1.518	....
July 3	1,370	D. 5.3	48	20	4.147	4.045	4.074	4.060	3.981	3.485	3.938	3.400	3.323	2.791	....
July 6	1,309	U. 4.0	48	30	4.087	3.946	4.117	4.194	4.073	3.747	4.181	4.037	3.690	....	....
July 8	1,200	D. 8.5	49	20	4.294	4.976	4.200	4.165	4.088	4.240	3.790	3.025	3.397	3.057	....
July 14	1,508	D. 7.5	49	40	....	....	....	....	2.518	2.770	2.780	2.385	2.339	2.081	....

August 15	1,606	D. 11.3	48	45	2.919	2.838	2.812	2.766	2.497	2.467	2.479	2.636	2.104	....	....
August 16	1,444	0	48	40	....	2.927	2.947	3.066	3.092	3.010	2.524	2.780	2.460	....	....
August 19	1,535	D. 10.8	50	30	....	2.493	2.638	2.899	2.968	2.594	2.743	2.592	2.468	....	....
August 20	1,544	U. 6.4	50	40	2.314	2.379	2.703	2.448	2.798	2.300	2.487	2.038	2.347	....	....
September 1	1,427	0	48	40	3.068	3.071	3.394	3.053	2.893	3.049	3.057	2.764	2.456	2.398	....
September 2	1,364	U. 9.0	48	40	....	3.228	3.164	2.964	2.952	3.223	3.019	2.834	2.548	1.894	....
September 3	1.238	D, 9.8	48	40	3.158	3.416	3.293	3.060	3.504	3.205	2.980	2.728	2.594	2.164	....
Sums	....	....	...	...	27.439	43.560	44.335	43.274	45.026	43.613	44.018	41.129	38.863	21.915	....
Means	....	....	...	...	3.429	3.351	3.410	3.329	3.463	3.115	3.144	2.937	2.776	2.435	....
July 1	1,685	D. 3.8	46	30	2.391	3.246	3.370	2.951	2.619	2.844	2.392	2.543	1.744	....	....
July 27	1,699	U. 0.8	45	30	2.668	3.027	2.761	2.933	2.715	2.600	2.388	2.031	....	....	....
August 10	1,701	U. 3.7	45	60	....	2.664	2.891	2.642	2.106	2.355	2.298	1.570	....	....	....
August 13	1,660	....	47	35	2.458	2.592	2.838	2.397	2.442	2.152	2.210	1.820	(m) 1.875	....	....
Sums	....	....	...	...	7.817	11.529	11.860	10.923	9.880	9.951	9.288	7.964	3.619	....	....
Means	....	U. 0.2	...	...	2.606	2.882	2.965	2.731	2.470	2.488	2.322	1.991	1.809	....	....

TABLE B.—*Sub-surface velocities in nearly the same depth of water, St. Lawrence River,* 1868.

Date.	Distance from base.	Wind in direction of river.	Depth of river.	Mean time, run in minutes.	Observed velocity of river at the following depths: 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
June 24	2,148	U. 6.0	81	6	......	1.534	1.519	1.522	1.545	1.507	1.451	1.455	1.463	1.329	1.455	1.438	1.434	1.254	1.002	1.011	......
June 29	2,014	D. 5.6	85	4	......	1.717	1.622	......	1.575	......	1.575	......	1.522	......	1.491	......	1.417	......	1.357	......	1.154
July 22	2,011	U. 5.5	84	5	......	1.564	1.534	1.579	1.632	1.623	1.618	1.686	1.636	1.530	1.542	1.579	1.575	1.519	1.507	1.349	1.251
Aug. 25	1,892	D. 6.0	81	10	......	1.737	1.760	1.687	1.655	1.577	1.551	1.587	1.462	1.598	1.455	1.483	1.590	1.382	......	......	......
Means.	......	D. 0.1	....	....	......	1.638	1.609	1.596	1.602	1.569	1.549	1.576	1.521	1.486	1.483	1.500	1.504	1.385	1.289	1.180	1.202
June 15	1,860	D. 11.2	78	4	......	1.552	1.575	1.621	1.593	1.571	1.571	1.519	1.419	1.543	1.566	1.538	1.474	1.289	1.135	......	......
June 15	2,130	D. 6.0	80	4	......	1.643	1.571	1.534	1.534	1.571	1.566	1.528	1.428	1.402	1.345	1.580	1.333	1.410	1.319	1.008	......
June 23	1,863	D. 3.8	79	6	......	1.560	1.645	......	1.534	......	1.519	......	1.560	......	1.511	......	1.445	......	1.056	......	......
June 29	1,806	D. 5.6	78	5	......	1.723	1.677	1.663	1.605	1.623	1.688	1.700	1.668	1.521	1.364	1.389	1.478	1.445	1.218	1.094	......
June 29	2,150	D. 5.7	80	4	......	1.710	1.623	1.564	1.556	1.584	1.463	1.550	1.552	1.507	1.515	1.410	1.323	......	......	......	......
July 7	1,955	0.0	79	5	......	1.690	1.609	1.645	1.623	1.564	1.564	1.519	1.564	1.545	1.465	1.511	1.465	1.417	1.383	1.128	......
July 8	2,116	U. 0.7	78	6	......	1.623	1.627	1.627	1.600	1.586	1.556	1.575	1.511	1.451	1.441	1.410	1.290	1.239	1.092	1.188	......
July 28	1,916	D. 6.6	78	5	......	1.627	1.618	1.681	1.860	1.5[illegible]4	1.600	1.618	1.489	1.575	1.597	1.493	1.538	1.538	1.392	1.458	......
July 29	2,121	0.0	78	5	......	1.609	1.519	1.476	1.511	1.545	1.614	1.511	1.479	1.455	1.438	1.424	1.389	1.511	1.507	1.259	......
Aug. 26	2,091	D. 8.9	80	8	......	1.585	1.505	1.493	1.503	1.497	1.507	1.457	1.408	1.364	1.385	1.313	1.200	1.320	1.244	1.054	......
Sept. 3	1,954	U. 6.0	78	6	......	1.515	1.560	1.500	1.538	1.515	1.538	1.357	1.357	1.309	1.234	1.241	1.397	1.357	1.400	1.227	......
Sept. 3	2,115	U. 5.5	80	5	......	1.597	1.647	1.650	1.632	1.668	1.593	1.668	1.609	1.600	1.511	1.511	1.479	1.307	1.326	1.306	1.142
Sept. 10	1,933	0.0	78	5	......	1.597	1.552	1.534	1.534	1.600	1.542	1.534	1.406	1.479	1.428	1.462	1.357	1.377	1.217	1.441	......
Sept. 10	2,097	0.0	80	5	......	1.715	1.632	1.677	1.526	1.609	1.560	1.549	1.486	1.522	1.663	1.483	1.414	1.410	1.386	1.270	......
Means.	......	D. 2.5	....	....	......	1.625	1.597	1.590	1.582	1.572	1.563	1.545	1.495	1.483	1.462	1.444	1.327	1.387	1.283	1.221	1.142
June 29	2,335	D. 6.5	75	5	......	1.700	1.720	1.661	1.627	1.526	1.500	1.571	1.509	1.415	1.380	1.380	1.289	1.178	1.053	......	......
July 13	2,040	D. 5.9	75	5	(1) 1.740	1.681	1.597	1.600	1.564	1.571	1.496	1.511	1.504	1.507	1.500	1.462	1.410	1.300	1.152	......	......
Aug. 20	1,969	U. 1.6	76	5	......	1.582	1.566	1.582	1.531	1.488	1.488	......	1.497	......	1.341	......	1.275	......	1.188	......	......
Means.	......	D. 3.6	....	....	(1) 1.740	1.654	1.628	1.621	1.574	1.528	1.495	1.541	1.503	1.461	1.410	1.421	1.325	1.239	1.131	......	......
July 11	1,805	D. 11.5	73	4	(1) 1.790	1.828	1.796	1.690	1.740	1.705	1.636	1.564	1.476	1.472	1.641	1.568	1.360	1.149	......	......	......
July 21	1,906	D. 9.2	73	5	......	1.730	1.668	......	1.593	......	1.645	......	1.564	......	1.431	......	1.424	......	1.306	......	......

Aug. 10	1,910	D. 1.5	73.5	6	......	1.700	1.638	1.605	1.545	1.542	1.489	1.445	1.458	1.421	1.451	1.403	1.400	1.363	1.229	......	......
Aug. 20	2,097	0.0	72	10	(s) 1.582	(10) 1.566	1.561	1.587	1.551	1.561	1.574	1.533	1.551	1.538	1.462	1.442	1.323	1.333	......	......	......
Aug. 25	1,680	D. 4.5	72	10	1.732	1.672	1.652	1.632	1.642	1.622	1.587	1.554	1.522	1.510	1.462	1.423	1.300	1.177	......	......	......
Aug. 28	2,312	D. 2.4	72	5	1.571	1.488	1.357	1.325	1.493	1.467	1.392	1.350	1.213	1.113	......	......	......	......	......	......	......
Sept. 3	2,316	U. 2.7	72	6	1.375	1.545	1.549	1.571	1.571	1.568	7.483	1.285	1.414	1.212	1.290	1.403	1.239	......	......	......	......
Sept. 10	2,305	D. 2.6	72	5	1.636	1.597	1.609	1.564	1.579	1.597	1.560	1.493	1.493	1.479	1.403	1.354	1.283	1.323	......	......	......
Means	......	D. 3.6	......	......	(1) 1.790	1.644	1.621	1.575	1.570	1.583	1.573	1.515	1.464	1.441	1.442	1.431	1.402	1.273	1.286	......	......
June 15	2,447	D. 0.9	70	5	......	1.689	1.582	......	1.526	......	1.645	......	1.479	......	1.311	......	......	......	......	......	......
June 16	3,110	0.0	69	5	......	1.584	1.575	1.534	1.511	1.515	1.439	1.402	1.340	1.283	1.183	1.148	0.831	......	......	......	......
June 16	3,331	0.0	69	5	......	1.470	1.436	1.439	1.474	1.362	1.394	1.383	1.305	1.283	1.195	1.143	0.954	......	......	......	......
June 16	3,508	0.0	69	5	......	1.319	1.439	1.423	1.419	1.431	1.376	1.351	1.340	1.272	1.198	1.113	1.006	......	......	......	......
June 24	2,416	U. 8.0	71	7	......	1.493	1.534	1.483	1.534	1.403	1.389	1.496	1.421	1.414	1.234	1.288	1.180	1.224	0.718	......	......
June 30	3,311	D.17.0	69	5	......	1.500	1.593	1.487	1.470	1.462	1.445	1.369	1.358	1.272	1.218	1.148	1.000	1.223	......	......	......
July 3	1,662	D. 1.1	70	5	......	1.600	1.650	1.705	1.605	1.564	1.549	1.605	1.586	......	1.351	......	1.374	......	......	......	......
July 7	1,768	D. 2.4	70	5	......	1.775	1.690	1.681	1.632	1.597	1.597	1.571	1.586	1.552	1.451	1.504	1.489	1.285	......	......	......
July 8	2,297	U.10.5	70	6	......	1.549	1.614	1.614	1.566	1.568	1.556	1.552	1.469	1.363	1.334	1.280	1.346	1.114	......	......	......
July 13	2,269	D. 8.3	71	6	(1) 1.839	1.695	1.641	1.614	1.564	1.597	1.530	1.504	1.469	1.476	1.504	1.589	1.543	1.162	(m) 1.202	......	......
July 28	1,731	D.13.3	70	5	......	1.597	1.605	1.507	1.575	1.659	1.500	1.542	1.609	1.489	1.421	1.417	1.346	1.354	(m) 1.140	......	......
July 29	2,303	0.0	70	5	......	1.522	1.515	1.579	1.568	1.511	1.549	1.530	1.519	1.507	1.472	1.496	1.366	1.229	......	......	......
Aug. 6	1,810	U. 2.7	71	5	......	1.632	1.672	1.681	1.681	1.672	1.695	1.654	1.614	1.623	1.586	1.614	1.465	1.434	1.334	......	......
Sept. 6	2,300	0.0	70	5	......	1.431	1.535	1.535	1.497	1.505	1.396	1.377	1.392	1.362	1.447	1.305	1.088	......	......	......	......
Sept. 10	1,745	0.0	70	5	......	1.564	1.549	1.568	1.578	1.593	1.586	1.582	1.568	1.556	1.500	1.571	1.465	1.340	......	......	......
Means	......	D. 1.5	......	......	(1) 1.839	1.561	1.575	1.561	1.547	1.531	1.510	1.494	1.470	1.419	1.360	1.340	1.239	1.252	1.099	......	......
June 16	2,635	0.0	67	5	......	1.583	1.580	1.571	1.524	1.534	1.534	1.419	1.289	1.270	1.168	1.094	......	......	......	......	......
June 16	2,822	0.0	66	5	......	1.419	1.524	1.471	1.428	1.428	1.423	1.410	1.345	1.333	1.219	1.057	......	......	......	......	......
June 24	2,590	U.11.0	66	6	......	1.493	1.469	1.458	1.571	1.575	1.511	1.424	1.360	1.246	1.168	1.114	0.717	......	......	......	......
June 24	3,124	U. 1.5	66	3	......	1.380	1.280	1.386	1.479	1.538	1.410	1.311	1.266	1.222	1.222	1.094	1.002	......	......	......	......
June 25	3,318	D. 1.5	56	7	......	1.491	1.369	1.434	1.329	1.377	1.400	1.397	1.326	1.217	1.027	0.950	0.685	......	......	......	......
25	3,515	D. 4.3	66	7	......	1.406	1.298	1.303	1.323	1.334	1.148	1.182	1.234	1.234	1.052	1.024	0.966	......	......	......	......
June 29	2,549	D. 7.4	67	4	......	1.575	1.580	......	1.562	......	1.571	......	1.483	......	1.326	......	1.138	......	......	......	......
June 30	2,776	0.0	67	6	......	1.575	1.545	1.507	1.530	1.552	1.526	1.493	1.445	1.414	1.311	1.229	0.989	......	......	......	......
30	2,998	D. 8.3	66	6	......	1.663	1.582	1.438	1.400	1.369	1.349	1.349	1.332	1.140	1.125	1.010	0.889	......	......	......	......
30	3,187	D.16.6	68	5	......	1.636	1.590	......	1.519	......	1.309	......	1.340	......	1.242	......	0.907	0.887	......	......	......
30	3,531	D. 9.7	66	5	......	1.562	1.344	1.351	1.394	1.373	1.394	1.354	1.326	1.264	1.218	1.171	0.895	......	......	......	......
July 8	2,460	U. 8.2	67	6	......	1.526	1.627	1.575	1.568	1.725	1.700	1.349	1.309	1.434	1.472	1.144	1.134	......	......	......	......
July 10	3,092	0.0	66	6	......	1.438	1.507	......	1.496	......	1.386	......	1.317	......	1.232	......	......	......	......	......	......
10	3,252	0.0	66	6	......	1.406	1.526	......	1.493	......	1.424	......	1.403	......	1.431	1.366	1.369	......	......	......	......
July 13	2,410	D.10.8	67	6	(1) 1.890	1.663	1.636	1.560	1.560	1.549	1.526	1.511	1.486	1.414	1.275	1.222	1.148	1.148	......	......	......
July 14	3,180	D. 7.1	68	7	(1) 1.632	1.568	1.530	1.507	1.448	1.438	1.343	1.397	1.326	1.314	1.176	1.116	0.937	0.933	......	......	......

TABLE B.—*Sub-surface velocities in nearly the same depth of water, St. Lawrence River*, 1868—Continued.

Date.		Distance from base.	Wind in direction of river.	Depth of river.	Mean time, run in minutes.	Observed velocity in river at the following depths:																
						0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
July	22	2,398	U. 5.0	66	5	......	1.593	1.618	1.618	1.515	1.534	1.605	1.493	1.579	1.519	1.504	1.263	1.372	1.244	......	......	......
	22	2,428	U. 4.6	67	5	......	1.560	1.597	1.745	......	......	......	......	......	......	......	......	......	......	......	......	......
July	24	3,314	0.0	66	6	......	1.489	1.522	1.496	1.462	1.383	1.351	1.354	1.349	1.369	1.217	1.237	1.154	......	......	......	......
July	31	2,492	D. 5.0	68	6	......	1.677	1.600	1.568	1.538	1.545	1.469	1.448	1.428	1.354	1.295	1.241	1.118	1.003	......	......	......
	31	2,694	D. 5.4	66	6	......	1.677	1.650	1.545	1.526	1.511	1.493	1.489	1.351	1.397	1.277	1.144	1.120	......	......	......	......
Aug.	3	2,910	0.0	66	6	......	1.575	1.575	1.560	1.522	1.472	1.469	1.500	1.400	1.346	1.331	1.320	1.142	......	......	......	......
Aug.	10	1,721	D. 0.5	66	5	......	1.534	1.455	1.534	1.495	1.479	1.479	1.462	1.500	1.469	1.428	1.465	1.241	......	......	......	......
	10	2,333	D. 8.3	67	6	......	1.545	1.542	......	1.519	......	1.515	......	1.436	......	1.402	......	1.270	1.170	......	......	......
Aug.	18	1,800	D. 9.2	67	10	......	1.790	1.846	1.805	1.758	1.632	1.642	......	......	......	......	......	......	......	......	......	......
Aug.	26	2,427	U. 1.6	67	5	......	1.657	1.642	1.598	1.556	1.515	1.525	1.500	1.505	1.402	1.382	1.285	1.233	......	......	......	......
Aug.	31	1,822	0.0	68	6	......	1.549	1.556	1.500	1.524	1.522	1.476	1.229	1.372	1.421	1.451	1.434	1.357	1.275	......	......	......
Sept.	3	2,380	0.0	66	6	......	1.560	1.383	1.560	1.542	1.522	1.465	1.406	1.380	1.428	1.369	1.229	1.104	......	......	......	......
Sept.	10	2,457	0.0	67	5	......	1.627	1.618	1.560	1.609	1.575	1.540	1.571	1.500	1.465	1.392	1.386	1.182	1.190	......	......	......
Sept.	11	2,666	D. 7.8	66	6	......	1.552	1.542	1.488	1.493	1.441	1.441	1.507	1.458	1.389	1.343	1.320	1.194	......	......	......	......
Means.		......	D. 2.3	......	......	(1) 1.761	1.557	1.538	1.526	1.472	1.497	1.497	1.415	1.392	1.350	1.306	1.205	1.173	1.106	......	......	......
June	23	1,621	0.0	64	6	......	1.618	1.627	1.590	1.609	1.582	1.534	1.534	1.445	1.366	1.337	1.082	0.854	......	......	......	......
June	24	2,900	0.0	65	6	......	1.320	1.458	1.406	1.448	1.574	1.383	1.357	1.314	1.270	1.128	1.076	0.928	......	......	......	......
June	25	3,716	D. 7.1	64	8	......	1.112	1.184	1.202	1.234	1.180	1.244	1.246	1.124	1.114	1.006	0.895	......	......	......	......	......
July	8	2,686	U. 6.0	64	6	......	1.519	1.489	1.556	1.511	1.575	1.571	1.476	1.351	1.583	1.261	1.180	0.901	......	......	......	......
July	10	2,908	0.0	63	6	......	1.575	1.586	1.538	1.530	1.519	1.472	1.389	1.394	1.329	1.212	......	......	......	......	......	......
	10	3,426	0.0	65	3	......	1.389	1.392	......	1.472	......	1.417	......	1.340	......	1.329	1.241	1.026	......	......	......	......
July	13	2,605	D. 12.4	63	6	(1) 1.785	1.755	1.534	1.504	1.351	1.472	1.417	1.314	1.360	1.239	1.132	0.952	......	......	......	......	......
	13	2,797	D. 14.0	64	6	......	1.600	1.586	......	1.479	......	1.366	......	1.380	......	1.261	......	0.990	......	......	......	......
July	14	2,973	D. 6.6	63	6	(1) 1.624	1.568	1.445	1.522	1.493	1.496	1.437	1.414	1.288	1.386	1.237	0.983	1.014	......	......	......	......
	14	3,328	D. 7.7	64	6	(1) 1.806	1.534	1.534	1.504	1.476	1.441	1.428	1.306	1.311	1.146	1.174	1.254	0.927	......	......	......	......
	14	3,512	D. 9.9	64	7	(1) 1.600	1.590	1.334	1.357	1.285	1.241	1.251	1.104	1.168	1.082	1.014	0.928	1.021	......	......	......	......
July	21	1,746	D. 6.9	65	5	(2) 1.800	1.740	1.659	1.597	1.695	1.726	1.632	1.605	1.579	1.522	1.641	1.507	1.455	......	......	......	......
July	22	2,618	U. 4.4	64	6	......	1.654	1.695	1.663	1.745	1.614	1.549	1.564	1.526	1.582	1.400	1.434	1.400	......	......	......	......

July	22	2,730	U. 4.2	63	6	......	1.534	1.522	1.681	1.650	1.654	1.545	1.560	1.564	1.493	1.400	1.314	1.268	......	......	......	......
July	24	3,478	D. 0.7	63	6	......	1.424	1.421	1.414	1.416	1.410	1.403	1.38[illegible]	1.346	1.357	1.266	1.074	1.120	......	......	......	......
	24	3,609	D. 1.4	64	6	......	1.377	1.394	1.394	1.400	1.354	1.354	1.334	1.329	1.224	1.241	1.156	1.070	......	......	......	......
Aug.	3	3,094	0.0	64	6	......	1.605	1.556	1.575	1.504	1.458	1.394	1.545	1.394	1.300	1.251	1.212	0.994	......	......	......	......
	3	3,280	0.0	64	6	......	1.627	1.552	1.552	1.496	1.476	1.421	1.377	1.406	......	1.343	......	1.118	......	......	......	......
	3	3,470	0.0	64	6	......	1.455	1.414	1.431	1.410	1.428	1.428	1.369	1.377	1.298	1.239	1.138	1.0[illegible]8	......	......	......	......
Aug.	13	3,253	0.0	63	5	......	1.285	1.341	1.351	1.402	1.341	1.418	1.413	1.402	1.382	1.351	1.249	1.172	......	......	......	......
Aug.	20	1,762	U. 3.2	64	10	......	1.652	1.670	1.543	1.462	1.564	1.630	1.590	1.551	1.580	1.460	1.450	1.367	......	......	......	......
Aug.	21	2,502	U. 3.6	65	10	......	1.520	1.510	1.528	1.525	1.481	1.491	1.423	1.390	1.400	1.351	1.277	1.156	......	......	......	......
	21	2,698	U. 3.3	64	8	......	1.598	1.582	1.550	1.515	1.493	1.472	1.426	1.354	1.300	1.280	1.062	1.153	......	......	......	......
	21	2,884	U. 3.0	65	10	......	1.587	1.569	1.535	1.505	1.488	1.467	1.431	1.392	1.367	1.313	1.202	1.088	......	......	......	......
	21	3,065	0.0	64	10	......	1.517	1.478	1.413	1.395	1.387	1.343	1.331	1.297	1.251	1.207	1.190	1.116	......	......	......	......
Aug.	22	3,290	0.0	64	8	......	1.569	1.476	1.546	1.470	1.385	1.325	1.292	1.221	1.153	1.070	1.025	0.937	......	......	......	......
	22	3,515	0.0	65	5	......	1.392	1.351	1.397	1.387	1.387	......	1.290	1.228	1.182	1.134	0.929	0.857	......	......	......	......
Sept.	4	2,720	0.0	64	6	......	1.582	1.493	1.530	1.455	1.500	1.455	1.458	1.434	1.417	1.383	1.259	1.168	......	......	......	......
	4	2,872	D. 2.1	64	5	......	1.506	1.538	1.524	1.462	1.515	1.424	1.462	1.414	1.377	1.351	1.253	1.110	......	......	......	......
	4	3,060	D. 1.5	63	3	......	1.568	1.479	1.479	1.515	1.479	1.545	1.403	1.386	1.340	1.270	1.098	0.948	......	......	......	......
	4	3,254	D. 1.0	63	6	......	1.472	1.366	1.441	1.472	1.431	1.406	1.400	1.400	1.283	1.285	1.116	1.054	......	......	......	......
	4	3,466	D. 0.5	64	6	......	1.410	1.400	......	1.346	......	1.317	......	1.317	......	1.311	......	1.102	......	......	......	......
Sept.	11	2,870	D. 7.8	65	6	......	1.568	1.530	1.486	1.530	1.458	1.451	1.462	1.363	1.277	1.152	1.132	1.118	......	......	......	......
	11	3,101	D. 5.5	65	6	......	1.489	1.283	1.383	1.445	1.386	1.369	1.366	1.351	1.295	1.311	1.182	1.124	......	......	......	......
	11	3,298	D. 2.7	64	7	......	1.351	1.457	1.445	1.434	1.329	1.261	1.237	1.360	1.178	1.266	1.146	1.056	......	......	......	......
	11	3,522	0.0	64	7	......	1.239	1.389	......	1.351	......	1.386	......	1.290	......	1.266	......	0.964	......	......	......	......
Means.		......	D. 1.7	......	......	(1) 1.723	1.510	1.480	1.489	1.468	1.457	1.420	1.402	1.365	1.325	1.268	1.161	1.078	......	......	......	......
June	17	3,750	D. 4.2	61	6	......	1.402	1.344	1.316	1.231	1.249	1.198	1.173	1.120	1.120	0.972	0.900	......	......	......	......	......
June	26	1,620	D.15.6	60	6	......	1.735	1.582	1.597	1.469	1.545	1.515	1.486	1.354	1.266	1.150	1.220	......	......	......	......	......
July	1	3,708	D.12.2	61	6	......	1.377	1.401	1.358	1.264	1.198	1.141	1.045	1.051	1.039	0.941	0.969	......	......	......	......	......
July	9	3,678	0.0	60	7	......	1.489	1.333	1.326	1.377	1.272	1.340	1.360	1.246	1.210	1.215	1.036	......	......	......	......	......
July	15	3,603	D. 7.9	61	6	(1) 1.530	1.496	1.438	1.357	1.386	1.372	1.366	1.298	1.170	1.244	1.112	1.065	......	......	......	......	......
July	23	3,002	U. 0.7	61	6	......	1.329	1.323	1.334	1.406	1.483	1.472	1.421	1.489	1.472	1.326	1.309	1.246	......	......	......	......
Aug.	3	3,630	0.0	62	6	......	1.290	1.298	1.326	1.259	1.389	1.337	1.337	1.295	1.270	1.270	1.190	......	......	......	......	......
Aug.	5	1,672	U. 1.9	61	5	......	1.668	1.725	1.730	1.690	1.641	1.614	1.568	1.590	1.540	1.545	1.538	1.500	......	......	......	......
Aug.	11	2,545	D. 1.7	62	7	......	1.575	1.532	1.500	1.493	1.455	1.434	1.366	1.283	1.293	1.168	1.198	1.065	......	......	......	......
Aug.	13	2,915	D. 5.0	60	10	......	......	1.556	......	1.505	......	1.439	......	1.405	......	1.318	......	......	......	......	......	......
	13	3,053	0.0	60	5	......	1.447	1.561	1.556	1.525	1.510	1.497	1.497	1.510	1.462	1.392	1.320	1.166	......	......	......	......
	13	3,465	0.0	60	6	......	......	1.279	......	1.373	......	1.360	......	1.313	......	1.223	......	......	......	......	......	......
Sept.	4	3,691	0.0	60	8	......	......	1.320	......	1.242	......	1.248	......	1.180	......	1.112	......	......	......	......	......	......
Sept.	12	3,750	U. 3.6	60	8	......	1.340	1.234	1.186	1.120	1.128	1.074	1.062	1.033	0.917	0.931	0.911	......	......	......	......	......
Means		......	D. 1.9	......	......	(1) 1.530	1.468	1.423	1.417	1.381	1.385	1.359	1.329	1.289	1.258	1.191	1.151	1.244	......	......	......	......
July	23	2,906	U. 3.0	57	6	......	1.542	1.472	1.496	1.556	1.597	1.618	1.549	1.542	1.383	1.357	1.259	......	......	......	......	......
July	24	3,718	D. 8.4	58	6	......	1.249	1.349	1.354	1.374	1.317	1.303	1.277	1.277	1.239	......	......	......	......	......	......	......
Aug.	13	2,719	D.10.0	57	8	......	1.617	1.607	1.586	1.589	1.546	1.515	1.464	1.441	1.355	1.252	1.083	......	......	......	......	......
Aug.	14	3,680	D. 8.6	58	10	......	1.413	1.395	1.338	1.313	1.259	1.193	1.193	1.175	1.097	1.006	0.768	......	......	......	......	......

TABLE B.—*Sub-surface velocities in nearly the same depth of water, St. Lawrence River*, 1868—Continued.

Date.	Distance from base.	Wind in direction of river.	Depth of river.	Mean time run in minutes.	Observed velocity of river at the following depths: 0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Aug. 22	3, 763	0. 0	58	10	......	1. 295	1. 221	1. 216	1. 110	1. 228	1. 318	1. 180	1. 124	1. 067	1. 083	0. 826	......	......	......	......	......
Means.	......	D. 4. 8	...	...	......	1. 425	1. 409	1. 398	1. 388	1. 389	1. 389	1. 333	1. 312	1. 228	1. 175	0. 984	......	......	......	......	......
June 17	3, 870	D. 6. 0	55	6	......	1. 287	1. 289	1. 155	1. 153	1. 143	1. 150	1. 045	1. 035	0. 883	......	......	......	......	......	......	......
July 1	3, 872	D.17. 6	55	7	......	1. 361	1. 234	1. 183	1. 150	1. 057	1. 031	0. 992	0. 943	0. 885	0. 835	......	......	......	......	......	......
July 9	3, 840	U. 2. 5	54	8	......	1. 392	1. 070	1. 184	1. 138	1. 142	1. 044	0. 959	1. 008	1. 096	0. 916	......	......	......	......	......	......
July 15	3, 800	D. 5. 0	55	5	(1) 1. 564	1. 374	1. 275	1. 239	1. 122	1. 095	1. 013	1. 033	1. 016	0. 936	1. 026	(54) 1. 000	......	......	......	......	......
Aug. 3	3, 875	0. 0	54	7	......	1. 180	1. 261	1. 261	1. 200	1. 212	1. 128	1. 146	1. 130	1. 068	0. 899	......	......	......	......	......	......
June 25	3, 917	D. 3. 5	52	8	......	1. 136	0. 956	0. 911	1. 084	1. 038	0. 946	0. 885	0. 837	0. 706	......	......	......	......	......	......	......
Aug. 22	3, 945	D. 1. 5	52	10	......	1. 182	1. 180	1. 065	1. 075	1. 083	1. 014	0. 976	0. 877	0. 793	......	......	......	......	......	......	......
Means.	......	D. 4. 4	...	...	(1) 1. 564	1. 273	1. 181	1. 145	1. 132	1. 110	1. 047	1. 005	0. 978	0. 900	0. 917	......	......	......	......	......	......
June 15	1, 540	D.11. 2	51	5	......	1. 698	1. 681	1. 621	1. 458	1. 453	1. 373	1. 374	1. 098	0. 512	......	......	......	......	......	......	......
July 3	1, 449	D.12. 4	49	6	......	1. 579	1. 168	1. 496	1. 504	1. 451	1. 496	1. 428	1. 317	1. 285	......	......	......	......	......	......	......
Aug. 18	1, 547	D. 6. 4	49	10	......	1. 677	1. 696	1. 635	1. 582	......	......	......	......	......	......	......	......	......	......	......	......
Sept. 12	3, 890	U. 4. 3	50	9	......	1. 144	1. 136	1. 057	1. 006	0. 980	0. 964	0. 890	0. 834	......	......	......	......	......	......	......	......
Means.	......	D. 6. 4	...	...	......	1. 525	1. 420	1. 452	1. 388	1. 295	1. 278	1. 231	1. 083	0. 899	......	......	......	......	......	......	......
June 17	4, 036	D. 9. 7	48	6	......	1. 193	1. 092	......	1. 178	......	0. 968	......	0. 778	......	......	......	......	......	......	......	......
June 25	4, 109	0. 0	45	7	......	0. 977	0. 800	0. 914	0. 904	0. 858	0. 737	0. 685	0. 432	......	......	......	......	......	......	......	......
July 1	4, 055	D.10 0	44	7	......	0. 812	1. 054	......	1. 118	......	1. 301	......	0. 960	......	......	......	......	......	......	......	......
July 11	1, 508	D. 7. 2	45	5	(4) 1. 839	1. 775	1. 775	1. 730	1. 672	1. 645	1. 571	1. 632	1. 351	1. 486	......	......	......	......	......	......	......
July 15	3, 950	D.13. 2	48	7	(1) 1. 272	1. 337	1. 241	1. 194	1. 170	1. 150	1. 098	1. 056	0. 842	0. 948	......	......	......	......	......	......	......
15	4, 100	0. 0	44	7	......	1. 118	1. 178	1. 082	1. 090	1. 014	0. 940	0. 912	0. 879	......	......	......	......	......	......	......	......
July 25	......	U. 0. 6	43	8	......	1. 079	1. 152	......	1. 178	......	0. 978	......	0. 963	......	......	......	......	......	......	......	......
July 28	1, 554	D. 4. 2	48	5	......	1. 745	1. 650	1. 575	1. 586	1. 545	1. 465	1. 428	1. 326	1. 298	......	......	......	......	......	......	......
Aug. 4	4, 190	U. 5. 1	44	9	......	1. 215	1. 196	1. 166	1. 040	1. 016	0. 940	0. 801	0. 823	......	......	......	......	......	......	......	......
Aug. 14	3, 901	D. 1. 8	48	10	......	1. 318	1. 250	1. 313	1. 198	1. 113	0. 968	0. 945	0. 836	0. 683	......	......	......	......	......	......	......

Aug. 25	1,476	D. 3.1	48	5	......	1.483	1.585	1.617	1.561	1.520	1.483	1.295	1.341	1.207	......	......	......	......	......	......	......
Aug. 31	1,518	0.0	45	6	......	1.597	1.575	1.496	1.519	1.445	1.438	1.275	1.128	......	......	......	......	......	......	......	......
Sept. 8	3,894	0.0	48	7	......	1.205	1.232	1.222	1.246	1.150	1.156	1.065	0.971	0.845	......	......	......	......	......	......	......
8	1,516	0.0	48	5	......	1.790	1.686	1.750	1.623	1.623	1.549	1.590	1.472	1.254	......	......	......	......	......	......	......
Means	......	D. 3.1	......	......	(1) 1.556	1.332	1.320	1.360	1.292	1.280	1.214	1.153	1.007	1.103	......	......	......	......	......	......	......
June 17	4,232	D. 11.6	41	10	......	0.617	0.827	0.810	0.842	0.775	0.739	0.674	......	......	......	......	......	......	......	......	......
July 9	4,326	U. 3.7	42	11	......	0.753	0.898	......	0.953	......	0.890	0.747	......	......	......	......	......	......	......	......	......
July 25	4,140	U. 1.0	43	8	......	1.079	1.153	......	1.178	......	0.978	......	0.963	......	......	......	......	......	......	......	......
Aug. 10	1,508	D. 1.0	43	5	......	1.672	1.590	1.593	1.519	1.560	1.410	1.207	......	......	......	......	......	......	......	......	......
Aug. 24	4,126	D. 9.5	42	10	......	1.302	1.216	1.097	1.020	0.892	0.814	......	......	......	......	......	......	......	......	......	......
Sept. 8	4,100	0.0	43	7	......	1.287	1.224	1.196	1.059	1.081	0.939	0.858	0.783	......	......	......	......	......	......	......	......
Sept. 12	4,083	U. 5.0	43	10	......	0.973	1.112	1.019	0.934	1.016	0.945	0.883	0.793	......	......	......	......	......	......	......	......
Means	......	D. 1.8	......	......	......	1.098	1.145	1.143	1.072	1.065	0.959	0.874	0.846	......	......	......	......	......	......	......	......

I remain, very respectfully, your obedient servant,

D. FARRAND HENRY.

Brevet Brigadier General W. F. RAYNOLDS,
Colonel Corps of Engineers, Detroit.

OFFICE LAKE SURVEY, *July* 1, 1869.

SIR: I have the honor to submit the following report on the meteorology of the lakes for the past year.

Tables A show the maxima, minima, and mean of the barometer and thermometer, and the amount of rainfall for the months, seasons, and years, for each year since the commencement of the observations.

In the following table I, is given the mean and range of the temperature at each of the stations which are arranged according to their respective latitudes.

TABLE I.

Stations.	Latitude.			Longitude.			Temperature.	
							Mean.	Range.
	°	′	″	°	′	″	°	°
Ontonagon	46	52	30	89	30	30	39.8	135
Superior	46	46	30	92	03	28	38.1	137
Marquette	46	32	51	87	22	57	41.3	136
Thunder Bay Island	45	02	13	83	02	34	42.5	118
Tawas City	44	15	57	83	30	54	44.2	115
Sackett's Harbor	43	55	00	75	57	00	45.5	129
Fort Niagara	43	15	00	79	55	00	47.2	111
Charlotte	43	12	54	77	51	00	47.6	121
Grand Haven	43	05	00	86	12	53	47.6	107
Milwaukee	43	03	00	87	55	00	46.1	127
Buffalo	42	53	00	78	55	00	46.9	118
Detroit	42	19	58	83	00	00	48.1	117
Monroe City	41	53	36	83	19	26	49.5	123
Cleveland	41	30	00	81	47	00	49.7	111

In Table II the stations are arranged according to their heights above the sea, and the mean and range of the barometer given for each place.

TABLE II.

Stations.	Height above the sea level.	Barometer + 28 inches.	
		Mean.	Range.
	Feet.		
Marquette	710	1.260	2.224
Superior	660	1.304	2.189
Ontonagon	630	1.306	2.273
Cleveland	629	1.336	1.997
Thunder Bay Island	610	1.355	2.079
Milwaukee	591	1.358	2.078
Grand Haven	588	1.369	1.896
Tawas City	583	1.353	2.552
Buffalo	569	1.356	2.136
Detroit	562	1.374	2.161
Monroe City	551	1.387	2.093
Charlotte	272.5	1.703	2.310
Sacket's Harbor	265.6	1.695	2.182
Fort Niagara	262.5	1.741	2.129

Tables C are condensed from tables B and show the maxima, minima, and mean of the observations for the whole time observed.

Tables III have been compiled from the reports of the Smithsonian Institution and of Toronto and other meteorological stations; and they show the mean monthly and yearly temperature for a series of years at a number of places in the neighborhood of the great lakes. They are graphically represented in the accompanying sketches on each of which the isothermal curves for two months, half a year apart, are given.

TABLE C.—*Maximum, minimum, and mean of the barometrical pressure reduced to 32° Fahrenheit +28 inches.*

	No. of y'rs.	January.			February.			March.			April.			May.			June.		
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Superior City	9	2.371	0.547	1.341	1.950	0.547	1.335	2.018	0.567	1.335	1.878	0.182	1.281	1.762	0.259	1.267	1.753	0.685	1.270
Ontonagon	9	2.430	0.359	1.311	1.949	0.444	1.354	1.929	0.400	1.324	1.859	0.157	1.280	1.897	0.214	1.274	1.896	0.412	1.287
Marquette	9	2.421	0.548	1.252	1.954	0.444	1.274	1.957	0.222	1.278	1.848	0.197	1.267	1.750	0.284	1.241	1.734	0.619	1.247
Milwaukee	9	2.503	0.665	1.400	1.989	0.529	1.408	1.888	0.582	1.341	1.999	0.425	1.326	1.750	0.447	1.292	1.730	0.770	1.332
Grand Haven	4	1.971	0.620	1.379	1.880	0.352	1.357	1.827	0.499	1.381	1.867	0.568	1.336	1.717	0.567	1.310	1.694	0.695	1.347
Thunder Bay Isl'd	7	1.979	0.563	1.352	1.992	0.551	1.344	1.887	0.050	1.279	1.984	0.481	1.351	1.842	0.530	1.323	1.824	0.732	1.349
Tawas	10	2.611	0.635	1.373	2.017	0.573	1.363	1.899	0.059	1.313	1.981	0.445	1.334	1.968	0.545	1.298	1.900	0.627	1.324
Detroit	10	2.630	0.656	1.405	2.073	0.566	1.403	1.872	0.469	1.341	1.958	0.562	1.333	1.752	0.656	1.301	1.782	0.680	1.318
Monroe	9	2.641	0.676	1.425	2.056	0.548	1.426	1.947	0.628	1.364	1.990	0.620	1.356	1.759	0.600	1.304	1.747	0.704	1.364
Cleveland	9	2.509	0.731	1.358	2.034	0.534	1.361	1.850	0.514	1.292	1.894	0.547	1.287	1.820	0.539	1.238	1.703	0.628	1.311
Buffalo	9	2.526	0.606	1.371	2.146	0.596	1.367	1.917	0.570	1.323	2.007	0.536	1.345	1.754	0.390	1.277	1.832	0.679	1.333
Fort Niagara	8	2.957	0.958	1.770	2.531	1.023	1.777	2.400	0.828	1.730	2.322	0.980	1.744	2.266	0.936	1.664	2.224	1.104	1.731
Charlotte	9	2.989	0.906	1.732	2.582	0.930	1.750	2.400	0.867	1.675	2.355	0.795	1.702	2.182	0.679	1.617	2.183	0.970	1.670
Sackett's Harbor	9	2.949	0.867	1.714	2.555	0.941	1.724	2.356	0.859	1.679	2.357	0.767	1.699	2.191	0.810	1.610	2.186	1.088	1.642

	No. of y'rs.	July.			August.			September.			October.			November.			December.		
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Superior City	9	1.765	0.692	1.276	1.650	0.800	1.307	1.839	0.674	1.307	2.026	0.388	1.318	2.004	0.393	1.280	2.019	0.393	1.339
Ontonagon	9	1.747	0.648	1.283	1.785	0.736	1.314	1.840	0.667	1.321	1.963	0.314	1.333						
Marquette	10	1.676	0.700	1.266	1.663	0.670	1.284	1.861	0.703	1.293	1.873	0.434	1.298	2.157	0.355	1.245	1.975	0.285	1.281
Milwaukee	10	1.696	0.902	1.352	1.702	0.971	1.366	1.828	0.803	1.375	2.014	0.658	1.384	2.040	0.549	1.335	2.032	0.552	1.387
Grand Haven	4	1.673	0.892	1.341	1.689	1.033	1.386	1.864	0.950	1.421	1.842	0.665	1.394	1.974	0.588	1.325	2.248	0.723	1.442
Thunder Bay Isl'd	7	1.806	0.782	1.351	1.690	0.809	1.372	1.903	0.753	1.404	1.950	0.658	1.362	2.129	0.421	1.326	2.069	0.519	1.383
Tawas	10	1.815	0.807	1.334	1.731	0.805	1.351	1.892	0.701	1.389	1.986	0.648	1.381	2.132	0.441		2.109	0.472	1.264
Detroit	9	1.692	0.933	1.367	1.786	0.946	1.392	1.869	0.983	1.431	1.979	0.708	1.420	2.099	0.637	1.369	2.039	0.636	1.413
Monroe	10	1.854	0.983	1.284	1.720	0.962	1.394	1.881	1.012	1.442	1.928	0.757	1.471	2.059	0.670	1.390	2.101	0.661	1.433
Cleveland	10	1.776	0.907	1.320	1.699	0.875	1.332	1.797	0.903	1.374	1.864	0.682	1.365	2.022	0.512	1.321	1.993	0.528	1.369
Buffalo	10	1.875	0.990	1.348	1.822	0.888	1.366	1.862	0.822	1.415	1.902	0.578	1.393	2.145	0.429	1.347	2.117	0.493	1.386
Fort Niagara	9	2.119	1.306	1.723	2.183	1.248	1.747	2.297	1.118	1.799	2.357	0.880	1.784	2.617	0.876	1.739	2.521	0.965	1.779
Charlotte	10	2.202	1.248	1.665	2.133	1.175	1.692	2.207	1.147	1.754	2.338	0.767	1.735	2.553	0.947	1.691	2.501	0.892	1.743
Sackett's Harbor	10	2.207	1.203	1.664	2.105	1.223	1.685	2.266	0.888	1.748	2.326	0.951	1.728	2.556	0.995	1.675	2.479	0.853	1.741

TABLE C.—*Yearly means and range of barometrical pressure reduced to 32° Fahrenheit + 28 inches.*

	1859.		1860.		1861.		1862.		1863.		1864.		1865.		1866.		1867.		1868.	
	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.
Superior City	......	(1.327)	1.276	1.544	1.274	1.724	1.324	1.355	1.322	1.583	1.288	1.315	1.308	1.487	1.318	1.766	1.292	1.485	1.344	1.768
Ontonagon	......	1.306	1.302	1.538	1.282	1.715	1.323	1.441	1.332	1.504	1.252	1.476	1.276	1.631	1.323	1.865	1.311	1.550	1.311	1.550
Marquette	......	......	1.271	1.598	1.268	1.673	1.289	1.622	1.313	1.421	1.179	1.428	1.252	1.650	1.259	1.987	1.256	1.534	1.309	1.757
Thunder Bay Island	1.358	2.019	1.321	1.503	1.335	1.449	1.309	1.429	1.375	1.458	1.312	1.520	(1.389)	......	......	......	......	......	......	......
Tawas City	1.368	2.073	1.342	1.465	1.341	1.444	1.376	1.475	1.399	1.389	1.314	1.598	1.384	1.483	1 348	2.139	1.299	1.378	......	1.529
Milwaukee	......	......	1.358	1.492	1.345	1.511	1.377	1.393	1.379	1.129	1.307	1.418	1.373	1.222	1.370	1.888	1.326	1.628	1.344	1.589
Grand Haven	......	......	1.353	1.560	1.346	1.527	1.360	1.434	......	......	......	......	......	......	......	......	......	......	......	......
Detroit	......	......	1.352	1.426	1.347	1.293	1.370	1.376	1.373	1.395	1.330	1.411	1.394	1.327	1.413	1.966	1.379	1.468	1.440	1.568
Monroe	......	......	1.395	1.413	1.392	1.313	1.420	1.398	1.410	1.364	1.335	1.404	1.401	1.323	1.393	2.041	1.371	1.413	1.398	1.261
Cleveland	......	......	1.317	1.442	1.308	1.285	1.331	1.385	1.343	1.340	1.267	1.465	1.338	1.413	1.341	1.970	1.331	1.500	1.364	1.509
Buffalo	......	......	1.367	1.354	1.357	1.653	1.382	1.481	1.397	1.610	1.282	1.564	1.379	1.437	1.346	2.033	1.329	1.344	1.357	1.511
Fort Niagara	......	......	......	......	1.707	1.530	1.746	1.712	1.749	1.494	1.683	1.310	1.739	1.573	1.771	1.979	1.781	1.340	1.841	1.404
Charlotte	......	......	1.665	1.405	1.679	1.783	1.707	1.608	1.749	1.787	1.641	1.659	1.738	1.652	1.715	2.164	1.709	1.607	1.735	1.515
Sackett's Harbor	......	......	1.675	1.456	1.683	1.636	1.710	1.689	1.737	1.732	1.632	1.516	1.703	1.459	1.703	2.182	1.688	1.559	1.722	1.551

TABLE C.—*Maximum, minimum, and mean barometrical pressure, reduced to 32° Fahrenheit, for seasons and years, + 28 inches.*

	Number of years.	Spring.			Summer.			Autumn.			Winter.			Years.			
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Range.
Superior City	9	2.018	0.182	1.294	1.765	0.685	1.284	2.026	0.388	1.302	2.371	0.393	1.338	2.371	0.182	1.304	2.189
Ontonagon	9	1.927	0.157	1.293	1.896	0.412	1.295	1.963	0.314	——	2.430	0.359	——	2.430	0.157	——	2.273
Marquette	9¼	1.957	0.197	1.262	1.734	0.619	1.232	2.157	0.355	1.279	2.421	0.285	1.269	2.421	0.197	1.260	2.224
Milwaukee	9½	1.999	0.425	1.320	1.730	0.770	1.350	2.040	0.549	1.365	2.503	0.529	1.398	2.503	0.425	1.358	2.078
Grand Haven	4	1.867	0.499	1.342	1.694	0.695	1.358	1.974	0.588	1.380	2.248	0.352	1.393	2.248	0.352	1.391	1.8966
Thunder Bay Island	7	1.984	0.050	1.318	1.824	0.732	1.357	2.129	0.421	1.364	2.069	0.519	1.360	2.129	0.050	1.366	2.079
Tawas	10	1.981	0.059	1.315	1.900	0.627	1.336	2.132	0.441	1.——	2.611	0.472	1.333	2.611	0.059	——	2.552
Detroit	9¼	1.958	0.469	1.325	1.786	0.680	1.359	2.099	0.637	1.406	2.630	0.566	1.407	2.630	0.469	1.374	2.161
Monroe	9¼	1.990	0.600	1.341	1.854	0.704	1.347	2.059	0.670	1.434	2.641	0.548	1.428	2.641	0.548	1.387	2.093
Cleveland	9¼	1.894	0.514	1.272	1.776	0.628	1.321	2.022	0.512	1.353	2.509	0.528	1.363	2.509	0.512	1.336	1.997
Buffalo	9½	2.007	0.390	1.315	1.875	0.679	1.349	2.145	0.429	1.385	2.526	0.493	1.375	2.526	0.390	1.356	2.136
Fort Niagara	8½	2.400	0.828	1.713	2.224	1.104	1.734	2.617	0.876	1.774	2.957	0.958	1.775	2.957	0.828	1.749	2.129
Charlotte	9¼	2.400	0.679	1.665	2.202	0.970	1.676	2.553	0.767	1.727	2.989	0.892	1.742	2.980	0.679	1.703	2.310
Sackett's Harbor	9½	2.357	0.767	1.669	2.207	1.088	1.664	2.550	0.868	1.717	2.949	0.853	1.730	2.949	0.767	1.695	2.182

TABLE C.—*Maximum, minimum, and mean temperature for months.*

	Number of years.	January.			February.			March.			April.			May.			June.		
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Superior	9	53	—37	11.6	55	—38	13.8	69	—24	23.0	70	—5	36.2	92	15	46.6	96	29	57.2
Ontonagon	9	45	—34	15.8	48	—37	13.8	61	—22	22.4	80	—5	36.8	94	18	47.7	97	30	59.5
Marquette	9	51	—31	17.7	53	—33	17.9	75	—19	25.3	74	3.	34.1	93	16	50.7	100.5	30	61.2
Milwaukee	9	50	—30	20.7	56	—18	24.6	70	— 7	32.0	76	16	42.8	91	27	50.8	97	39	64.5
Grand Haven	4	65	— 5	25.8	52	—16	25.5	63	— 1	33.0	76	8	45.2	88	27	56.1	88	28	65.4
Thunder Bay Island	7	47	—17	22.7	47	—25	22.7	49	—11.5	28.5	62	8	37.0	72	25	46.5	90	35	57.2
Tawas	10	......	—25	21.3	......	—25	22.9	......	—10	30.3	......	9	39.7	......	17	51.1	......	27	62.2
Detroit	10	63	—19	26.5	64	—14	27.5	75	— 9	34.6	89	12	45.9	87	25	57.3	95	38	66.1
Monroe	9	73	—17	25.0	61	—21	28.1	75	—19	34.8	78	8	45.8	92	29	58.2	101	38	69.8
Cleveland	9	66	—14	25.8	71	—14	29.3	76	— 8	35.7	84	17	47.2	91	28	57.6	95	39	68.5
Buffalo	9	60	—13	24.1	63	—22	25.7	67	— 7	30.1	77	12	43.3	86	23	53.6	96	28	65.0
Fort Niagara	8	56	— 9	25.3	60	—15	25.9	63	— 1	31.2	75	14	40.9	82	18	51.2	90	22	63.8
Charlotte	9	64	—15	25.2	58	—20	27.4	71	—15	33.4	78	7	44.4	84	13	51.2	93	30	66.3
Sackett's Harbor	9	58	—36	20.5	52	—46	21.2	69	—34	30.5	74	7	43.5	81	25	54.5	88	36	65.0

	Number of years.	July.			August.			September.			October.			November.			December.		
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Superior	10	99	35	64.2	97	33	63.8	88	20	54.0	84	12	43.0	66	—19	30.4	49	—31	13.8
Ontonagon	9	97	30	64.9	98	33	63.7	90.5	20.0	55.4	88.5	4	43.0	69	— 4	33.0	......	......	......
Marquette	10	103	33	66.3	100	38	66.3	93	20.3	56.5	85	15	44.6	69	— 4	33.5	60.5	—19	21.5
Milwaukee	10	97	44	68.7	97	41	67.4	91	31	60.8	80	21	48.5	69	— 3	37.8	59	—19	24.9
Grand Haven	4	90	33	70.1	91	48	70.3	81	28	60.4	75	17	49.8	62	+ 9	38.0	57	0	28.7
Thunder Bay Island	7	90	41	64.1	93	40	65.6	81	33	57.7	72.5	26	46.3	60.5	8	36.9	51	— 5	26.0
Tawas	10	......	33	68.4	......	31.5	66.8	......	28	58.8	......	20	47.2	......	......	(37.0)	......	— 6	25.3
Detroit	9	96	43	71.2	98	37	69.1	91	29	61.4	82	14	49.8	77	7	39.1	65	— 6	29.2
Monroe	10	103	41	74.9	99	34	72.4	98	27	63.6	89	16	51.7	71	5	40.6	59	—13	28.9
Cleveland	10	97	48	73.1	93	43	71.2	88	35	63.7	85	27	52.2	75	5	42.0	68	— 9	30.1
Buffalo	10	93	45	70.4	94	39	68.8	90	28	61.2	80	24	50.4	73	9	39.9	61	— 9	28.0
Fort Niagara	10	96	51	70.7	89	46	69.1	88	33	60.7	82	25	49.7	70	12	39.6	63	— 8	27.9
Charlotte	10	99	38	71.4	99	35	70.1	92	26	62.1	84	15	50.4	73	4	40.6	66	—22	28.9
Sackett's Harbor	10	91	48	70.7	93	40	69.0	88	28	61.5	82	16	49.6	73	8	38.4	61	—30	25.3

TABLE C.—*Yearly mean and range of temperature.*

	1859.		1860.		1861.		1862.		1863.		1864.		1865.		1866.		1867.		1868.	
	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.	Mean.	Range.
Superior City	......	......	39.2	120	38.1	120	37.6	121	39.0	132	38.8	134	39.3	120	37.4	130	37.4	109	37.1	129
Ontonagon	......	......	40.3	109	40.5	132	38.6	119	40.3	103	40.6	132	......	......	......	......	39.2	—	—	......
Marquette	......	......	41.0	109	41.0	130	40.1	121	41.8	120	42.7	132	43.3	112.5	40.8	126	41.9	112.5	41.8	126
Thunder Bay Island	41.3	84	41.7	82	42.6	107	42.9	95	42.9	87	43.2	113	(43.8)	93.5	......	......	......	......	......	......
Tawas City	44.4	89	44.7	95	44.5	110	43.9	95	44.1	96	44.3	106	44.7	95	43.4	—	44.6	—	......	......
Milwaukee	......	......	46.8	99	46.6	113	45.5	114	46.6	103	44.9	127	46.0	103	44.4	115	45.3	110	44.2	110
Grand Haven	......	......	47.3	86	47.4	107	47.2	94	......	......	......	......	......	......	......	......	......	......	......	......
Detroit	......	......	47.8	103	48.7	112	48.3	94	48.4	94	48.1	114	49.3	96	46.0	106	46.8	107	45.8	109
Monroe	......	......	48.7	104	49.3	108	49.6	101	49.4	104	49.5	117	50.6	105	49.4	124	50.9	115	49.6	122
Cleveland	......	......	49.8	87	50.4	104	49.4	89	49.5	88	49.5	108	50.9	101	49.2	111	49.7	97	49.5	102
Buffalo	......	......	47.1	93	47.4	109	47.6	93	47.5	94	46.8	105	47.4	103	45.5	93	46.0	90	44.5	99
Fort Niagara	......	......	46.2	86	46.5	103	47.0	93	46.5	82	46.9	100	47.0	88	46.4	96	45.1	86	45.0	95
Charlotte	......	......	47.5	90	47.3	110	47.8	94	48.4	107	48.8	111	49.3	115	47.6	120	48.3	106	47.4	114
Sackett's Harbor	......	......	46.3	108	45.0	131	45.8	109	47.1	127	48.4	116	48.4	129	47.2	118	45.1	120	43.5	116

TABLE C.—*Maximum, minimum, and mean temperature for seasons and years.*

	Number of years.	Spring.			Summer.			Autumn.			Winter.			Years.			Range.
		Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	
Superior City	9½	92	—24	35.3	99	29	61.7	88	—19	42.5	55	—38	12.9	99	—38	38.8	137
Ontonagon	9	94	—22	35.6	98	30	62.7	90.5	—4	43.8	48	—37	—	98	—37	—	135
Marquette	9½	93	—19	36.7	103	30	64.6	93	—4	44.9	60.5	—33	19.0	103	—33	41.3	136
Milwaukee	9½	91	—7	41.9	97	39	66.9	91	—3	49.0	59	—30	26.7	97	—30	46.1	127
Grand Haven	4	88	1	44.8	91	28	68.6	81	9	49.4	65	—16	26.6	91	—16	47.3	107
Thunder Bay Island	7	72	—11.5	37.3	93	35	62.3	81	8	47.0	51	—25	23.8	93	—25	42.6	118
Tawas	10	—	—10	40.4	—	27	65.8	—	—	(47.3)	—	—25	23.1	—	—25	(44.1)	......
Detroit	9½	87	—9	45.9	98	37	68.8	91	7	50.1	65	—19	27.7	98	—19	48.1	117
Monroe	9½	92	—19	46.3	103	34	72.4	98	5	52.0	73	—21	27.2	103	—21	49.5	123
Cleveland	9½	91	—8	46.8	97	39	70.9	88	5	52.6	71	—14	28.3	97	—14	49.7	111
Buffalo	9½	86	—7	42.3	96	28	68.9	90	9	50.5	63	—22	25.9	96	—22	46.9	118
Fort Niagara	9½	82	1	41.1	96	22	71.2	88	12	50.0	63	—15	26.4	96	—15	47.2	111
Charlotte	9½	84	—15	43.0	99	30	69.3	92	4	51.9	66	—22	27.2	99	—22	47.0	121
Sackett's Harbor	9½	81	—34	41.9	93	36	68.2	88	8	49.8	61	—36	22.3	93	—46	45.5	139

TABLE C.—*Mean amount of rain and melted snow in United States inches, and decimals, for months, seasons, and years.*

	No. of years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Spring.	Summer.	Autumn.	Winter.	Years.
Superior	9	0.83	1.45	1.29	1.85	2.42	2.88	3.58	2.84	3.62	2.27	1.14	0.82	5.79	9.53	7.03	3.13	25.44
Ontonagon	9	2.39	1.35	1.22	1.49	1.93	2.25	2.68	2.39	2.72	2.17	1.47	2.25	4.64	7.52	6.22	....	....
Marquette	9	1.94	2.07	1.92	2.15	1.76	2.88	2.73	2.89	2.64	2.78	2.51	2.13	5.61	8.38	7.96	6.15	28.02
Milwaukee	9	2.15	1.72	2.35	2.28	3.37	2.99	3.46	2.35	2.97	2.18	2.11	1.87	8.22	9.05	7.34	5.85	30.25
Grand Haven	4	1.62	1.28	1.16	1.06	3.11	1.68	2.22	3.87	2.60	2.32	2.79	1.73	5.33	8.59	7.72	4.64	25.32
Thunder Bay Island	7	3.20	2.65	2.83	3.07	2.07	2.33	2.86	2.25	3.84	2.79	2.45	2.89	7.97	7.44	9.08	8.25	33.22
Tawas	10	1.55	0.98	2.06	2.16	1.69	1.99	1.64	2.33	2.32	1.79	1.70	....	5.91	5.96	5.82	3.70	....
Detroit	9	1.27	1.49	2.77	2.37	2.86	3.15	2.95	3.02	3.21	2.66	2.17	1.89	7.98	9.10	8.05	4.75	30.00
Monroe	9	1.52	1.56	2.53	2.64	2.86	2.99	3.07	3.14	3.55	2.20	2.16	2.04	8.15	9.35	7.90	1.93	39.70
Cleveland	9	2.86	2.29	3.21	3.26	3.53	3.51	2.73	3.01	3.99	3.04	3.52	3.15	10.00	9.39	10.21	8.62	37.91
Buffalo	9	2.11	1.77	2.95	2.42	3.23	1.72	2.39	2.99	2.72	2.81	2.64	2.66	8.00	7.21	9.17	6.66	32.00
Fort Niagara	9	1.91	1.79	2.46	1.88	2.84	1.55	2.46	2.26	2.53	2.49	2.65	2.10	6.73	6.47	7.41	5.91	26.20
Charlotte	9	1.86	1.70	2.26	2.09	3.27	2.15	2.57	2.62	2.97	2.68	2.53	2.40	7.62	7.20	8.18	5.84	29.00
Sackett's Harbor	9	1.91	2.48	2.64	2.77	3.65	2.24	2.81	3.00	3.39	2.58	4.26	2.68	9.06	8.16	10.94	7.25	35.60

TABLE III.—*Mean monthly temperature at various places in the neighborhood of the great lakes.*

Name of station.	Latitude.	Longitude.	No. of years observed.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
	° ′ ″	° ′ ″		°	°	°	°	°	°	°	°	°	°	°	°	°
Chromedale	39 55	75 25	4	27.99	30.34	35.68	46.55	58.72	70.59	75.25	70.20	63.89	54.09	41.34	37.41	51.00
Philadelphia	39 57	75 11	6	30.56	32.45	40.34	51.16	62.84	72.88	78.78	74.76	68.30	55.52	45.52	35.09	54.02
Paradise	40 00	76 08	5	24.20	24.60	29.20	41.00	64.00	76.60	82.00	77.00	72.00	59.00	37.40	29.60	51.43
Zanesville	40 00	82 01	4	27.31	31.50	33.45	55.15	61.77	70.53	77.49	74.65	69.64	53.94	43.04	32.13	52.55
Bedford	40 01	78 30	6	26.01	27.11	34.46	48.99	60.85	70.61	76.05	70.66	64.12	51.22	40.36	31.23	50.14
Somerset	40 02	79 02	4	31.60	27.84	38.00	46.34	57.95	67.37	71.65	67.27	60.01	48.53	37.31	29.76	48.64
Granville	40 03	82 34	4	22.96	30.61	35.53	53.12	60.69	69.22	74.16	69.00	67.46	52.81	41.48	30.51	50.63
Urbana	40 06	83 43	6	25.76	28.74	37.34	49.73	61.43	70.21	75.41	71.71	65.81	51.74	39.06	29.52	50.54
West Urbana	40 09	88 17	3	31.47	26.23	43.09	46.96	60.48	70.34	77.40	74.23	66.06	51.96	38.41	29.91	51.38
Augusta	40 12	89 45	6	24.37	27.80	39.88	49.20	62.71	69.12	75.30	71.83	64.50	52.02	39.59	23.38	49.98
Harrisburg	40 16	76 50	6	30.03	31.15	40.11	51.45	64.47	74.16	79.37	75.01	68.68	66.46	44.83	34.21	55.00
Canonsburg	40 17	80 10	2	15.84	30.40	30.91	39.81	56.23	66.61	71.85	68.35	64.58	51.51	39.40	30.68	47.18
Carthage	40 23	91 17	2	24.53	30.10	42.64	46.65	66.97	70.25	79.14	75.55	66.11	53.97	35.28	30.15	51.78
Peoria	40 36	89 30	4	23.46	28.97	38.49	49.83	61.55	73.83	78.51	74.25	66.70	53.89	38.16	27.59	51.27
New York	40 42	74 01	4	28.96	29.09	35.40	47.26	59.01	69.51	75.99	72.52	66.42	54.94	44.49	34.02	51.47
Logansport	40 45	86 14	4	27.34	31.50	41.10	47.12	60.19	69.83	76.45	73.30	66.13	52.76	38.52	31.77	51.33
New Lisbon	40 45	80 46	4	30.34	31.47	40.06	50.39	63.82	73.32	77.22	73.62	64.75	52.21	40.26	35.19	52.74
Lewisburg	40 55	76 58	4	23.22	27.65	34.49	46.69	58.75	69.64	74.25	69.33	61.75	49.40	39.64	29.99	48.73
Fairfield	41 01	91 57	5	22.69	24.92	37.00	49.91	61.62	70.64	76.63	70.22	65.44	52.28	34.85	25.18	49.33
Ottawa	41 20	88 47	6	21.53	24.97	35.66	48.81	59.74	70.12	75.77	71.78	64.58	51.95	35.58	25.04	48.71
Oberlin	41 20	82 15	4	21.87	26.28	32.68	46.61	57.51	68.23	74.63	70.67	66.43	50.68	39.98	29.93	48.80
Hiram	41 20	81 15	4	22.59	26.79	32.99	44.32	54.92	68.03	72.63	67.66	62.90	51.69	36.58	31.28	47.70
Beverly	41 22	74 00	6	24.71	26.32	34.27	45.63	57.54	66.79	73.40	70.02	62.58	51.05	41.54	24.72	48.22
Muscatine	41 26	91 05	6	17.94	22.27	33.81	46.60	57.57	68.13	73.25	66.48	63.72	50.37	35.23	23.02	46.53
Cleveland	41 30	81 40	10	25.79	29.34	35.76	47.18	57.61	66.31	73.05	70.92	63.72	52.18	42.00	30.14	49.50
Meadville	41 39	80 11	4	19.86	24.52	28.53	43.80	56.20	67.24	72.66	64.44	62.47	47.86	38.10	29.05	46.24
Perrysburg	41 39	83 40	5	25.55	26.79	36.43	50.46	61.01	72.03	77.58	71.67	67.29	53.98	40.47	31.04	51.19
Aurora	41 40	88 16	3	29.42	23.14	39.12	45.46	58.20	67.45	72.68	60.43	61.72	49.45	37.95	22.23	48.03
Michigan City	41 41	86 53	3	24.33	27.15	34.22	42.99	53.24	67.86	72.63	69.64	63.66	50.11	37.91	26.22	47.49
Collingwood	41 49	83 43	4	27.02	30.30	38.40	47.03	58.89	68.59	72.81	69.85	62.89	51.49	38.44	29.25	49.56
Madison	41 52	81 00	6	27.68	27.91	36.89	44.90	56.17	67.53	73.02	69.95	63.94	49.83	38.59	29.71	48.85
Monroe	41 56	83 22	10	25.05	28.12	34.73	40.71	58.19	69.76	74.86	72.39	63.61	51.66	40.53	28.87	49.54
Marengo	42 14	88 38	4	21.83	23.79	35.56	43.58	56.27	69.56	75.06	69.94	62.95	47.84	34.18	23.28	47.15
Bellevue	42 15	90 25	4	17.23	29.47	33.28	43.31	57.71	69.17	74.35	70.34	62.00	49.69	33.40	20.36	46.69
Ann Arbor	42 16	83 40	4	19.73	19.23	29.60	47.44	57.38	67.94	73.47	68.97	65.22	55.31	37.55	22.48	47.03
Battle Creek	42 20	85 10	6	22.96	24.20	33.33	44.99	57.70	68.28	74.70	70.64	64.18	49.93	37.45	27.01	47.94
Detroit	42 24	83 00	10	26.57	27.49	34.50	45.89	57.27	60.13	71.22	69.11	61.38	49.76	39.09	28.34	47.57
Saugatuck	42 30	85 50	3	17.78	23.72	31.91	49.35	55.57	65.21	75.04	72.08	68.00	54.56	41.93	29.88	48.75
Beloit	42 30	89 04	6	18.25	21.12	32.99	45.74	57.02	68.23	74.49	70.91	62.64	49.33	34.69	22.67	46.58
Kenosha	42 35	87 50	4	22.38	25.08	34.60	41.24	52.64	64.16	71.73	69.61	60.69	48.06	37.60	23.57	46.04

Lodi	42 37	76 54	3	22.07	18.58	72.99	43.70	55.96	66.54	73.53	67.77	62.27	49.69	38.11	25.59	45.98
Cooper	42 40	85 31	5	21.42	22.78	30.11	45.53	54.33	68.07	74.76	68.64	63.02	49.51	34.85	29.01	46.09
Poultney	42 40	91 21	5	12.42	16.57	31.41	45.79	60.16	67.19	72.63	69.69	63.71	49.31	33.68	20.92	45.29
Ovid	42 41	76 52	4	20.33	25.24	26.35	41.53	53.26	65.07	72.70	68.78	61.77	47.85	38.61	29.08	45.88
Zanesville	42 42	89 91	6	15.83	18.96	28.84	45.01	57.03	68.91	74.57	70.43	62.89	48.50	34.51	22.94	45.70
Platteville	42 45	90 00	6	15.54	20.26	33.15	43.57	60.72	70.52	77.37	73.49	54.93	51.46	34.01	20.44	46.29
Norway	42 50	88 10	2	8.11	27.55	27.37	47.11	56.96	71.14	74.56	68.58	59.46	50.45	34.43	16.22	45.16
Buffalo	42 53	79 33	10	24.15	25.69	30.12	43.27	53.59	64.96	70.40	68.73	61.07	49.18	39.85	28.04	46.59
Flint	42 58	83 39	2	22.85	19.68	33.15	43.07	59.80	66.90	74.11	70.93	64.38	49.06	36.92	25.03	47.57
Grand Rapids	43 00	86 00	6	22.66	20.71	31.04	45.25	57.81	66.76	73.53	68.47	63.86	48.15	36.35	26.17	46.73
Grand Haven	43 01	86 11	4	25.80	25.52	32.97	45.25	56.07	65.40	70.12	68.82	60.37	49.82	38.00	28.72	47.24
Wampsville	43 04	75 50	5	21.70	24.17	30.36	43.36	57.30	65.55	72.40	67.08	60.58	47.69	36.42	25.32	45.99
Milwaukee	43 04	87 59	10	20.69	24.60	31.99	42.81	52.53	64.42	67.61	68.30	60.72	48.55	37.80	24.97	45.42
Baldwinsville	43 04	76 41	5	22.08	22.20	28.24	41.52	54.25	63.63	70.76	65.68	60.13	48.42	37.91	26.80	45.14
Madison	43 05	90 13	6	23.30	22.33	32.34	43.00	57.07	68.13	74.88	69.18	64.28	49.33	32.53	22.45	46.57
Rochester	43 08	77 51	4	23.38	26.46	32.92	44.24	56.97	67.97	73.39	69.01	61.85	48.86	38.65	28.06	47.48
Rossville	43 10	91 21	3	22.16	18.27	36.92	40.40	55.50	63.98	74.05	71.11	59.40	46.64	31.29	19.66	44.95
Charlotte	43 14	77 51	10	25.20	27.40	33.42	44.37	54.60	66.30	71.43	70.04	62.18	50.49	40.56	28.96	47.91
Hamilton	43 15	79 57	5	23.10	24.32	30.79	43.49	54.16	65.69	72.67	70.00	62.70	50.73	35.68	29.20	46.92
Fort Niagara	43 18	79 08	10	25.29	25.84	31.22	40.84	51.13	63.79	70.57	69.02	60.67	49.76	39.67	27.96	46.31
Oswego	43 28	76 34	6	23.48	24.13	30.92	40.64	53.94	61.20	69.87	67.40	60.99	47.80	39.28	27.55	45.00
Toronto	43 39	79 21	25	23.53	23.02	29.40	40.99	51.09	61.38	67.07	66.06	57.98	46.04	36.86	26.11	44.13
Houseville	43 40	75 32	5	21.20	27.08	34.65	42.33	50.49	66.54	73.53	67.77	62.27	49.09	38.11	25.59	45.98
Sackett's Harbor	43 55	75 57	10	20.47	23.07	30.59	43.24	54.42	64.94	70.71	[illegible]	61.54	49.78	39.31	25.50	46.12
Manitowoc	44 07	87 37	4	20.67	23.92	32.02	40.43	50.66	62.20	69.38	66.42	58.15	46.92	34.95	25.19	44.24
Appleton	44 10	88 35	4	15.99	19.57	30.18	40.84	54.48	66.50	72.35	67.88	59.46	47.31	32.36	20.06	43.92
Tawas	44 15 57	83 30 54	10	21.29	22.96	30.34	39.69	51.09	62.08	68.33	66.76	58.77	47.21	35.77	23.01	43.96
Canton	44 38	75 15	4	17.40	14.55	26.08	43.00	56.72	66.51	72.96	67.23	59.38	48.74	36.57	17.19	43.86
Ogdensburg	44 43	75 26														
Thunder Bay	45 02	83 09	7	22.67	22.71	28.50	36.97	46.54	57.24	64.11	65.57	57.67	46.30	36.94	26.04	42.44
St. James	45 44	85 27	3	18.01	13.67	24.08	39.04	50.07	59.04	68.24	66.47	60.87	48.11	36.32	23.69	42.30
Sault Ste. Marie	46 20	84 10														
Marquette	46 32	87 41	3	22.09	16.33	29.77	35.43	47.17	57.22	64.47	64.45	55.95	44.04	30.58	21.54	40.75
Bay City	46 33	91 00	4	15.89	12.38	25.95	31.41	43.93	56.63	67.74	62.95	54.01	40.04	25.53	14.72	37.52
Superior City	46 38	92 03	10	11.58	13.80	23.82	36.20	46.59	56.51	64.10	63.82	53.93	42.93	30.40	14.16	38.15
Ontonagon	46 52	89 30	10	15.79	15.66	22.51	36.60	46.63	59.58	64.92	64.25	55.69	43.98	29.58	17.37	39.55
Beaver Bay	47 12	91 19	2	12.76	14.74	28.68	32.56	46.33	51.60	60.03	60.23	50.43	39.58	27.87	11.51	36.38
Copper Falls	47 25	88 16	2	8.28	12.06	18.33	32.23	47.13	57.24	66.38	61.89	51.09	42.37	28.90	17.22	36.93
Eagle River	47 26	88 02	2	11.53	12.23	20.33	40.23	49.50	62.36	68.16	61.08	54.61	47.21	29.63	18.20	39.58

Though the observations are not taken at enough places, nor generally extended through a sufficient number of years to give the differences of temperature with a great deal of accuracy, yet we can see from the tables and sketches the great influence the lakes have upon the temperature in their vicinity.

The tables also show another effect, which it was almost impossible to show by the curves on so small a scale; that is, the higher temperature in winter and lower in summer of places on the lake shore compared with that of places twenty or fifty miles inland.

The general form of the curves for the seasons will be seen to be about as follows:

Winter—January, February, December.—The first three curves rise a little near Lake Superior, and then drop toward the eastern end of Lake Ontario. The next two or three rise rapidly and pass through the northern part of Lakes Michigan and Huron, and then slightly drop toward the eastern end of Lake Ontario. The next is inflected nearly the same but in less degree, and the lower nearly straight.

Spring—March, April, May.—The upper and lower curves are about the same as those of winter, but the center ones have a tendency to drop round the south end of Lake Michigan, and then rising in the lower peninsula of Michigan, drop again round Lake Erie, and then rise parallel to Lake Ontario.

Summer—June, July, August.—The first curves pass near the west end of Lake Superior, then drop round the south end of Lake Huron and rise to the eastern end of Lake Ontario. In the middle curves the deflection round the south end of Lake Michigan, the rise between Lakes Michigan and Huron, and the further deflection round Lakes Erie and Ontario, are more marked than in the spring curves. The lower curves are nearly parallel to the lines of latitude, but slightly inflected, the same as the middle ones.

Autumn—September, October, November.—The higher curves rise slightly toward the western end of Lake Superior, then drop north of Lake Huron to the eastern end of Lake Ontario. The next rise rapidly; passing through the northern part of Lake Michigan, are deflected downward to Lake Erie, and rise again toward the eastern end of Lake Ontario. The next are slightly inflected in the same manner as the last, and the lowest are nearly straight, bending a little south in the center.

Thus the effect of these large bodies of water is to depress the summer and to elevate the winter curves, making the climate in their neighborhood more equable.

It will be noticed that some of the summer curves run almost all around Lakes Michigan and Erie, while the winter curves rise far up into the lower peninsula of Michigan. This shows why, as has long been known to agriculturists, wheat and corn can be as easily raised in the northern portion of this peninsula as two or three degrees of latitude to the south. in Central Illinois or Ohio.

Cleveland, which is about sixty miles south of Detroit, has nearly the same mean temperature, while Buffalo, which is about forty miles north of Detroit, has its mean temperature nearly three degrees less.

I hope at some future day to have fuller records of the temperature, and may then be able to correct some of the irregularities of the present curves.

In Table IV will be found the continuation of record of daily evaporation for the past year, that for the winter months being computed from the temperature according to the method adopted in the last report. As mentioned last year, these evaporators are usually placed on top of

the meteorological house, and are fully exposed to the sun. The temperature of the water is, therefore, greater than that of the lake surface, and the evaporation proportionately large.

From the few observations made in 1867, I estimated the evaporation from the lake surface to be sixty-four per cent. of that recorded by the evaporators. The more extended observations made this year show that that estimate was too large.

In Tables XXXIX, XL, and XLI of my report on the out-flow of the lakes for 1868 are given the simultaneous readings of an evaporator placed as usual at the stations and one in the river.

In the St. Lawrence the river evaporator was so protected that continuous readings could be taken, but at the other places the incessant passage of steamers made it very difficult to keep the evaporator from being disturbed by their waves, and on a great many days the readings were rendered worthless. But there are, I think, enough results to show that the river evaporation is about one-half that in the ordinary evaporators.

The temperature of the water in the rivers is generally higher than the lake surface, and, therefore, the evaporation should be greater, but the evaporation recorded at the river stations is for some reason greater than that recorded at the stations on the lakes, so that the excess will probably balance, and I have therefore taken fifty per cent. of the evaporation as recorded in Table V as the true evaporation.

TABLE IV.—*Mean daily evaporation for each month in decimals of an inch.*

SUPERIOR, WISCONSIN.

[For the months of January, February, March, April, November, and December the evaporation was computed from the mean temperature.]

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1862..	0.009	0.007	0.023	0.034	0.116	0.124	0.136	0.117	0.098	0.045	0.027	0.021	0.063
1863..	0. 19	0.014	0.023	0.039	0.120	0.175	0.135	0.190	0.095	0.046	0.029	0.020	0.075
1864..	0.014	0.020	0.023	0.036	0.127	0.168	0.145	0.135	0.083	0.049	0.029	0.010	0.070
1865..	0.011	0.019	0.022	0.035	0.127	0.130	0.159	0.135	0.134	0.052	0.038	0.011	0.073
1866..	0.010	0.009	0.017	0.036	0.110	0.145	0.161	0.099	0.080	0.068	0.031	0.015	0.066
1867..	0.008	0.013	0.015	0.039	0.103	0.172	0.183	0.159	0.082	0.058	0.032	0.012	0.074
1868..	0.008	0.010	0.027	0.033	0.049	0.143	0.138	0.135	0.071	0.078	0.030	0.017	0.061
Mean	0.011	0.013	0.022	0.036	0.107	0.151	0.151	0.138	0.093	0.056	0.031	0.016	0.069

ONTONAGON, MICHIGAN.

[For the months of January, February, March, April, May, November, and December the evaporation was computed from the mean temperature.]

1861..	.....	....	......	.....	......	.....	....	......	0.100	0.074	0.032	0.019	......
1862..	0.013	0.008	0.023	0.035	0.047	0.129	0.144	0.121	0.101	0.090	0.030	0.024	0.064
1863..	0.023	0.018	0.023	0.042	0.052	0.136	0.110	0.074	0.090	0.101	0.031	0.023	0.062
1864..	0.015	0.020	0.022	0.036	0.050	0.200	0.202	0.093	0.085	0.083	0.031	0.016	0.075
1865..	0.015	0.021	0.022	0.036	0.119	0.183	......	......	......	......	......	......	......
Mean	.....	......	......	......	......	......	......	......	......	......	......	......	......

MILWAUKEE, WISCONSIN.

[For the months of January, February, March, November, and December the evaporation was computed from the mean temperature.]

1862...	0.020	0.019	0.032	0.112	0.158	0.179	0.204	0.197	0.142	0.088	0.038	0.031	0.102
1863...	0.030	0.031	0.031	0.131	0.122	0.178	0.164	0.153	0.135	0.049	0.040	0,029	0.091
1864...	0.019	0.026	0.031	0.079	0.218	0.248	0.173	0.151	0.071	0.041	0.039	0.021	0.090
1865...	0.019	0.027	0.032	0.144	0.143	0.156	0.165	0.157	0.079	0.060	0.044	0.023	0.087
1866...	0.020	0.019	0.027	0.150	0.182	0.189	0.229	0.135	0.091	0.074	0.051	0.023	0.098
1867...	0.017	0.027	0.026	0.114	0.098	0.210	0.231	0.218	0.155	0.095	0.073	0.026	0.107
1868...	0.017	0.021	0.036	0.127	0.133	0.207	0.221	0.161	0.091	0.046	0.037	0.022	0.093
Mean.	0.020	0.025	0.031	0.123	0.150	0.194	0.198	0.168	0.109	0.065	0.046	0.025	0.095

TABLE IV.—*Mean daily evaporation, &c.*—Continued.

TAWAS, MICHIGAN.

[For the months of January, February, March, April, November, and December the evaporation was computed from the mean temperature.]

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1861..	......	......	......	......	......	......	......	......	0.059	0.045	0.047	0.032	..
1862..	0.021	0.021	0.029	0.039	0.144	0.165	0.171	0.172	0.098	0.064	0.045	0.030	0.092
1863..	0.028	0.025	0.028	0.040	0.151	0.148	0.167	0.122	0.101	0.072	0.037	0.028	0.071
1864..	0.022	0.026	0.028	0.033	0.213	0.205	0.226	0.216	0.139	0.101	0.036	0.023	0.106
1865..	0.019	0.023	0.031	0.042	0.216	0.224	0.210	0.236	0.170	0.157	0.031	0.026	0.10[illegible]
Mean	0.022	0.024	0.029	0.040	0.179	0.185	0.193	0.187	0.113	0.088	0.039	0.028	0.094

THUNDER BAY ISLAND, MICHIGAN.

[For the months of January, February, March, and December the evaporation was computed from the mean temperature.]

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1861...	......	......	......	......	......	......	......	0.184	0.119	0.121	0.105	0.032	....
1862...	0.023	0.020	0.030	0.130	0.140	0.205	0.187	0.228	0.147	0.135	0.075	0.030	0.114
1863...	0.028	0.024	0.026	0.141	0.136	0.197	0.209	0.158	0.128	0.084	0.100	0.028	0.105
1864...	0.022	0.024	0.026	0.137	0.141	0.191	0.187	0.199	0.119	0.082	0.040	0.024	0.104
1865...	0.019	0.024	0.030	0.155	0.151	0.150	0.192	0.183	0.140	0.149	0.122	0.026	0.111
Mean .	0.023	0.023	0.028	0.141	0.142	0.186	0.194	0.190	0.131	0.118	0.086	0.028	0.108

DETROIT, MICHIGAN.

[For the months of January, February, March, and December the evaporation was computed from the mean temperature.]

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1861...	0.024	0.030	0.031	0.141	0.162	0.220	0.238	0.168	0.111	0.063	0.042	0.035	0.107
1862...	0.024	0.025	0.042	0.133	0.207	0.191	0.202	0.230	0.134	0.035	0.050	0.033	0.113
1863...	0.031	0.027	0.031	0.145	0.207	0.184	0.191	0.158	0.122	0.041	0.042	0.032	0.104
1864...	0.025	0.029	0.033	0.134	0.182	0.240	0.214	0.199	0.111	0.048	0.038	0.025	0.107
Mean .	0.026	0.033	0.032	0.138	0.189	0.204	0.211	0.180	0.119	0.072	0.043	0.032	0.108

MONROE, MICHIGAN.

[For the months of January, February, March, November, and December the evaporation was computed from the mean temperature.]

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1863...	0.031	0.028	0.032	0.095	0.200	0.202	0.197	0.208	0.123	0.074	0.075	0.033	0.108
1864...	0.026	0.031	0.033	0.085	0.182	0.244	0.230	0.173	0.120	0.058	0.039	0.027	0.105
1865...	0.023	0.029	0.039	0.126	0.161	0.219	0.161	0.161	0.141	0.037	0.040	0.029	0.101
1866...	0.024	0.026	0.032	0.199	0.188	0.205	0.203	0.110	0.039	0.076	0.041	0.028	0.105
1867...	0.024	0.034	0.032	0.144	0.144	0.2[illegible]8	0.186	0.180	0.130	0.104	0.043	0.029	0.105
1868...	0.022	0.024	0.040	0.151	0.133	0.183	0.204	0.121	0.102	0.041	0.041	0.027	0.095
Mean .	0.025	0.029	0.035	0.133	0.169	0.213	0.197	0.165	0.120	0.062	0.045	0.029	0.104

CLEVELAND, OHIO.

[For the months of January, February, March, and December the evaporation was computed from the mean temperature.]

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1861...	......	......	......	......	......	......	0.180	0.162	0.105	0.059	0.048	0.037	.....
1862...	0.027	0.027	0.033	0.129	0.166	0.162	0.192	0.195	0.125	0.077	0.065	0.035	0.103
1863...	0.032	0.029	0.032	0.104	0.187	0.188	0.159	0.163	0.041	0.050	0.040	0.034	0.092
1864...	0.027	0.030	0.035	0.087	0.123	0.158	0.172	0.129	0.080	0.042	0.048	0.028	0.080
1865...	0.021	0.027	0.039	0.091	0.125	0.165	0.138	0.113	0.032	0.053	0.031	0.032	0.076
1866...	0.026	0.023	0.033	0.126	0.124	0.159	0.173	0.104	0.052	0.051	0.034	0.026	0.079
1867...	0.021	0.035	0.032	0.104	0.100	0.141	0.161	0.158	0.113	0.055	0.042	0.029	0.083
1868...	0.023	0.025	0.040	0.109	0.098	0.130	0.166	0.113	0.042	0.045	0.044	0.028	0.075
Mean .	0.026	0.028	0.035	0.107	0.132	0.157	0.168	0.141	0.081	0.054	0.044	0.031	0.084

TABLE V.—*Showing the corrected daily evaporation, daily amount of rain, and mean temperature at the several lake survey meteorological stations for different years.*

SUPERIOR, WISCONSIN.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1862	0.031	0.062	2.00	37.6	1213
1863	0.038	0.047	1.24	39.0	1026
1864	0.035	0.057	1.61	38.8	1109
1865	0.036	0.082	2.28	39.3	1092
1866	0.033	0.071	2.15	37.4	1133
1867	0.037	0.077	2.0	37.4	1011
1868	0.030	0.056	1.5	37.1	1233
Mean ...	0.034	0.065	1.87	38.1	1117

ONTONAGON, MICHIGAN.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1862	0.032	0.074	2.31	38.6	1206
1863	0.031	0.064	2.09	40.3	1300
1864	0.037	0.063	1.70	40.6	1098
Mean ...	0.033	0.067	2.03	39.8	1201

MILWAUKEE, WISCONSIN.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1862	0.051	0.107	2.09	45.5	892
1863	0.045	0.089	1.98	46.6	1036
1864	0.045	0.076	1.69	44.9	998
1865	0.044	0.082	1.87	46.0	1043
1866	0.049	0.091	1.86	44.0	906
1867	0.058	0.068	1.18	45.3	781
1868	0.047	0.080	1.70	44.2	940
Mean ...	0.048	0.085	1.77	45.3	942

TAWAS, MICHIGAN.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1862	0.041	0.068	1.66	43.9	1070
1863	0.039	0.085	2.18	44.1	1131
1864	0.053	0.052	0.98	44.3	836
1865	0.054	0.075	1.39	44.7	828
Mean ..	0.047	0.070	1.55	44.2	965

THUNDER BAY ISLAND, MICHIGAN.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1862....	0.057	0.101	1.79	42.9	753
1863....	0.052	0.086	1.65	42.9	825
1864....	0.052	0.087	1.67	43.2	831
1865....	0.055	0.086	1.60	43.8	797
Mean ..	0.054	0.090	1.68	43.2	801

DETROIT, MICHIGAN.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1861....	0.053	0.105	1.98	48.7	919
1862....	0.057	0.086	1.51	48.3	849
1863....	0.052	0.083	1.60	48.4	931
1864....	0.053	0.071	1.34	48.1	908
Mean ..	0.054	0.086	1.61	48.4	902

MONROE, MICHIGAN.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1863....	0.054	0.084	1.56	49.4	915
1864....	0.052	0.080	1.54	49.5	952
1865....	0.051	0.091	1.78	50.6	992
1866 ...	0.052	0.085	1.63	49.4	950
1867....	0.053	0.072	1.36	50.9	960
1868 ...	0.047	0.085	1.81	49.6	1055
Mean ..	0.051	0.083	1.61	49.9	970

CLEVELAND, OHIO.

Year.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
1862....	0.062	0.113	1.81	49.4	797
1863 ...	0.055	0.100	1.82	49.5	900
1864....	0.048	0.094	1.96	49.5	1031
1865....	0.046	0.090	1.96	50.9	1107
1866 ...	0.048	0.132	2.74	49.2	1025
1867 ...	0.050	0.093	1.86	49.7	994
1868....	0.045	0.106	2.36	49.5	1100
Mean ..	0.051	0.104	2.07	49.7	993

The above Table V shows the evaporation, as corrected according to the before mentioned river observations, together with its relation to the rain-fall and temperature. The following table, VI, is compiled from the last, and gives the evaporation, &c., for the several lake stations, arranged according to their latitudes.

TABLE VI.—*Showing the mean daily evaporation, amount of rain, and temperature at the several lake survey meteorological stations.*

Stations.	Latitude.	Longitude.	Daily evaporation.	Daily rain.	Ratio of rain and evaporation.	Mean temperature.	Ratio of temperature and evaporation.
	° ′ ″	° ′ ″					
Ontonagon	46 52 30	89 33 30	0.033	0.067	2.03	39.8	1201
Superior	46 46 30	92 03 28	0.034	0.065	1.87	38.1	1117
Thunder Bay Island	45 02 13	86 11 26	0.054	0.090	1.64	43.2	801
Tawas	44 15 57	83 30 54	0.047	0 070	1.55	44.2	946
Milwaukee	43 03 —	87 55 —	0.048	0.085	1.77	45.3	942
Detroit	42 19 58	83 00 00	0.054	0.086	1.61	48.4	[illegible]
Monroe	41 53 36	83 19 26	0.051	0.083	1.61	49.9	973
Cleveland	41 30 —	81 47 —	0.051	0.104	2.07	49.7	960

In the following Table VII is given the corrected mean daily evaporation, temperature, and rain-fall for each lake.

In the upper lakes these quantities are found by taking a mean of the different stations on the lake, but, as mentioned in the last report, we have no record of the evaporation on Lake Ontario, and, for that lake, it has been computed from the temperature and latitude, according to the ratio shown in table.

TABLE VII.—*Showing the mean daily evaporation, amount of rain, and temperature for the several lakes.*

Lakes.	Latitude.		Longitude.		Daily evaporation.	Daily rain.	Mean temperature.
	From—	To—	From—	To—			
	° ′	° ′	° ′	° ′			
Superior	46 30	48 30	84 00	92 00	0.033	0.0770	38.4
Michigan	41 30	46 00	85 00	88 00	0.048	0.0839	45.4
Huron	43 00	46 00	80 00	85 00	0.050	0.0765	43.2
Erie	41 30	43 00	79 00	83 30	0.051	0.0892	48.3
Ontario	43 00	44 00	76 00	80 00	0.049	0.0892	46.7

The rain-fall in the preceding table is not taken from that given in tables, but from Table XXXVII, in the report on the outflow of the lakes, giving the rain-fall for the whole lake region.

That table was compiled from all the data to which I had access; but Professor Joseph Henry informs me that he is about to publish a work on the rain-fall of the United States, compiled from the records of the Smithsonian Institution, which will probably contain much additional information on this subject, though it will hardly give what is most needed, the rain-fall of the country north of the lakes, and which would probably decrease the amounts given in table.

I remain, very respectfully, your obedient servant,

D. FARRAND HENRY.

Bvt. Brig. Gen. W. F. REYNOLDS,

Colonel Corps of Engineers, Detroit.

APPENDIX Y.

OFFICE OF PUBLIC BUILDINGS, GROUNDS, AND WORKS,
United States Capitol, Washington City, D. C., August 1, 1869.

GENERAL: The accompanying annual report, in relation to the preparation of the different maps of campaigns and battle-fields which were compiled from the field-notes of surveys made under my direction, is respectfully furnished for your information. The maps, including all those portions of the country over which the surveys have actually been extended, and which comprise, with one or two exceptions, the entire field of operations of the contending armies from Antietam to Appomattox Court House, have been completed.

The first of the series of maps prepared exhibit principally the movements of the army south of the Rapidan; and the last ones, which have just been finished, comprise several of the battle-fields north of that river and along the Rappahannock; Antietam and Harper's Ferry are included among them.

It may be interesting to give a brief recapitulation of the work, its arrangement and extent, and to offer a few suggestions as to a plan for its future continuance and completion.

The surveys cover an extent of nearly fifteen hundred square miles. The following statement furnishes a list of the number of maps which have been prepared, comprising a portfolio of one hundred and eighty-six sheets:

1. The general maps, two inches to the mile, represent the reduced detailed surveys of the country between Cold Harbor and Appomattox Court House, numbering thirteen sheets.

2. The detailed maps are on a scale of eight inches to the mile, twenty-nine in number; eight of which represent the intrenched lines in front of Petersburg, and the remainder those around Richmond and along the James River.

3. Sixteen sheets, scale of four inches to the mile, exhibit the most prominent battle-fields, comprising Fredericksburg, Chancellorsville, Wilderness, Mine Run, Todd's Tavern, Spottsylvania Court House, North Anna, Tolopotomy, Cold Harbor, Five Forks, Jetersville, Sailor's Creek, Farmville, Appomattox Court House, Harper's Ferry, and Antietam.

4. Thirteen sheets, one inch to the mile, show the original maps issued at the commencement of the campaign of 1864.

5. Three sheets of sections of those last mentioned, corrected and distributed on the march.

6. One hundred and eleven drawings of forts, redoubts, batteries, and mines, the scale of the respective plans being forty feet to one inch.

7. The index map, scale $\frac{1}{250000}$, is a general map of the country lying east of the Alleghany Mountains, and extending from the battle-field of Gettysburg, on the north, to the South Side railroad, on the south.

The material collected during the surveys has been entirely exhausted. The general map, which is intended to accompany and form an index for the detailed sheets, is still in course of construction. Its completion has been delayed in consequence of the absence of the correct data to enable a connection to be formed between the several surveys that have already been made; this can only be obtained by a further prosecution of the field-work. Reference is respectfully made to the recommendations that appear in my last annual report, and to the plan proposed in a communication on the subject which was addressed to the Chief of Engineers on the 7th of last May. In that letter it was stated that the colored portions of the general map which accompanied it, "present a

diagram of the theater of operations; certain spaces exhibit the sections already surveyed and mapped, and others present the additional localities which should be surveyed in order to prepare and complete the sheets necessary to fully illustrate the history of the several campaigns." The party, as organized by me in the summer of 1868, surveyed in forty-six working days an area of one hundred and eighty-eight square miles, comprising the battle-fields of Fredericksburg, Chancellorsville, Wilderness, Mine Run, and North Anna. A similarly organized party should, according to past experience, be able to survey about one hundred square miles per month. As there still remain between nine hundred and one thousand square miles, it will require from nine to ten months to complete the field-work. Could the necessary transportation be temporarily furnished by the officers of the Quartermaster's Department at such military posts as may be convenient to the work, and could subsistence be supplied from the nearest subsistence depots, the cost of the survey would be very considerably reduced. The necessary rodmen, instrument bearers, and flagmen of the party could be detailed, as formerly, from the engineer battalion. The pay and incidental expenses of the principal and assistants of the party would be alone required to prosecute the work. An appropriation of fifteen thousand dollars is respectfully asked for the same to be applied during the coming year.

I am, general, very respectfully, your obedient servant,

N. MICHLER,
Major of Engineers, Bvt. Brig. Gen. U. S. A.

Bvt. Maj. Gen. A. A. HUMPHREYS,
Brigadier General and Chief of Engineers,
Office of the Chief of Engineers, Washington, D. C.